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CONTENTS

Morrison Charophyta from Wyoming ..... *Raymond E. Peck* 83

Cretaceous and Tertiary Foraminifera from Southern Santa Clara Province, Cuba ..... *A. A. Thiadens* 91

Notes on Some Interesting Cretaceous and Tertiary Foraminifera from the West Indies ..... *Shoshiro Hanzawa* 110

Fusulinids of the Subfamily Schubertellinae ..... *M. L. Thompson* 118

Middle Permian Fusulinids from Szechuan, China ... *M. L. Thompson and C. L. Foster* 126

Middle Tertiary Ostracoda of the Genus *Cytheridea* ..... *Morton B. Stephenson* 145

SOCIETY RECORDS AND ACTIVITIES
Members of the Society of Economic Paleontologists and Mineralogists 160

JOURNAL of PALEONTOLOGY

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PAGE

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MORRISON CHAROPHYTA FROM WYOMING

RAYMOND E. PECK

ABSTRACT

One new genus (*Aclistochara*) and nine new species of charophytes, represented by oogonia, are described from the Morrison (Jurassic?) formation of Wyoming. The oogonia were collected at two widely separated localities, each locality yielding a distinctive assemblage of species. However, the assemblages as a whole are similar and indicate that this group of fossils may be of value in correlating continental deposits of Mesozoic age.

Correlation of continental deposits other than lacustrine is often difficult. Fossils in such formations are usually rare and those that are found are seldom of stratigraphic value. Ordinarily they are neither sufficiently distinctive nor widely enough distributed to be of much aid. Correlation by the most abundant fresh-water invertebrates, the mollusks, is extremely difficult and often impossible. The genera are long-lived, the species ordinarily are only of local distribution, and in many cases preservation is so poor that identification is not practical.

Ostracoda have been utilized to some extent and seem to offer a fertile field for investigation. As yet, however, there is hardly enough known concerning the vertical and horizontal distribution of fresh-water ostracodes to evaluate them properly.

The vertebrates, especially the fishes, are occasionally of value, but most vertebrates are neither widely distributed geographically nor abundant in the formations in which they occur.

Plants are of some value in correlating continental deposits but the conditions necessary for the preservation of most plants are so seldom attained that they are not common fossils.

One group of plants that does seem to offer possibilities in the correlation of fresh-water strata is the Charophyta. Charophytes are small aquatic plants that, in many cases, secrete an incrustation of calcium carbonate over the entire organism and within the enveloping cells of the oogonia. On the death of the plant this incrustation usually breaks down to form a fine-grained calcareous mud and the only recognizable organic remains are the peculiarly spiralled "lime-shells" of the oogonia. These "lime-shells" possess many characters that allow them to be easily differentiated into species with short vertical ranges, as illustrated by the studies of Reid and Groves (1921) on the lower Headon beds (Eocene) of England and of Dolfuss and Fritel (1919) on the Tertiary beds of the Paris Basin. The genera and species of living Charophyta are widespread geographically and the growing record of fossil representatives indicates that they were likewise widely distributed. Charophyte oogonia and ostracodes are the only fresh-water fossils likely to be recorded

in a recognizable state from drill samples.

Although charophyte oogonia are abundant in Tertiary deposits and many species have been described, Mesozoic Charophyta have been generally neglected by paleontologists. A recent summary by Groves (1933, p. 5) lists six valid species from the Mesozoic of Europe, three from North America, two from South America, and one from India. There has been no attempt made to study these forms systematically and determine their distribution.

The scarcity of Mesozoic charophyte oogonia may be more apparent than real. Two samples containing oogonia from widely separated localities in the Morrison formation have recently been given to me. One sample was collected near Mayoworth, Wyoming, by C. C. Branson, who, in his paper on the pelecypods and ostracodes of the Morrison (1935, p. 514), describes the occurrence as a "fossiliferous lens of argillaceous sand about a foot thick, lying near the middle of the Morrison and a few feet above a dinosaur-bearing member."

The other sample was collected by Carl Jones and Beverly Bradish, graduate students at the University of Missouri, near Bell Springs, about 18 miles northwest of Rawlins in Carbon County, Wyoming. The Sundance-Morrison contact is questionable in this area. Both formations consist largely of greenish sands and shales, and fossils are abundant only in restricted zones. Dobbin, Hoots, and Dane (1927) defined the upper limit of the Sundance (Jurassic) formation as the top of the second limestone above the Chugwater formation. This limestone contains many *Camptonectes* sp. Green sandstones and shales, 234 feet in thickness, occurring between this "*Camptonectes*-limestone" and the overlying thick basal conglomerate of the Cloverly formation were referred to the Morrison. The sample containing the charophyte oogonia was taken from a green shale, 5 feet thick, 20 feet above the limestone defined as the top of the Sundance.

Of the ten species that comprise this Morrison assemblage, only one was found in both localities, but the assemblages from both localities have many features in common. All the oogonia are small, many have cellular furrows (for explanation of terminology see Peck, 1934, p. 104), and eight of the species are referred to a new genus. The new genus also includes previously described oogonia from both older and younger formations.

SYSTEMATIC DESCRIPTIONS

CHAROPHYTA

Family CHARACEAE

Genus CHARA Vaillant, 1719

CHARA VERTICILLATA Peck, n. sp.

Plate 14, figures 30–33

Oogonia ellipsoid with flattened to gently rounded ends, small, ranging from 0.5 mm. to 0.6 mm. in length, the long axis of the ellipse approximately one-fifth greater than maximum diameter, greatest diameter at mid-height. Spiral ridges cellular in position, broad, gently convex, crossing the equator of the oogonium at an angle of about 18 degrees and completing approximately two turns.

Eleven spirals visible in lateral view. Narrow, shallow furrows mark the lateral contacts of the cells.

Remarks.—*C. verticillata* is the most common type of oogonium found in the Morrison near Mayoworth, Wyoming, and approximately nine out of every ten specimens examined belong to it. There is little variation in size and shape, but a few individuals are almost as broad as long.

Several recorded species of *Chara* from other localities and horizons closely resemble *C. verticillata* in size and shape. *C. stantoni* Knowlton (1893) from the Bear River Cretaceous is longer in relation to width, has only eight or nine spirals visible in a side view, and has cellular furrows instead of cellular ridges. Usually there is considerable variation within a species in the amount of calcium carbonate deposited in the enveloping cells, and fossil oogonia belonging to the same species may have either cellular ridges or cellular furrows. Sometimes, however, this is a constant character. I have examined approximately 50 specimens of *C. verticillata* and all have cellular ridges. I have not had the opportunity of examining specimens of *C. stantoni*, but the illustrations show cellular furrows and Knowlton describes the species as having "cells furrowed."

C. laevigata Upton from the Inferior Oolite of England has more acutely rounded ends and has, according to Groves (1933, p. 22), a marked projection at the base. *C. gardnerae* Groves from the Midway formation of Texas has thirteen spiral ridges visible in a side view.

Occurrence.—Near the middle of the Morrison formation about 3 miles south of Mayoworth, Wyoming.

Syntypes.—Univ. Missouri, 31011–4.

CHARA VOLUTA Peck, n. sp.

Plate 14, figures 16–19

Oogonia small, measuring about 0.35 mm. in length and 0.3 mm. in diameter, broadly ellipsoid, the sides converging regularly from the greatest diameter at mid-height to the somewhat obtusely rounded base and summit. Spiral ridges intercellular in position, narrow and fairly sharp, separated by broad, shallow cellular furrows. The spirals complete almost two turns around the oogonium, and about nine or ten ridges are visible in a lateral view.

Remarks.—This description is based on three specimens. Because of the cellular furrows and the consequent thinness of the "lime-shell" all of the specimens are somewhat crushed. The one that seems to have more nearly retained its original shape is chosen as the holotype. There is considerable variation among the three specimens in the angle of ascension of the spirals. If more and better preserved material could be examined, it might be found that this is a character that should be used to divide these forms into at least two species. However, as the three specimens are the only representatives of the genus *Chara* from this locality and as they resemble each other closely in size, shape, and number of spirals visible in a side view, it is considered probable that they represent the same species.

The size, shape, and number of spiral ridges visible in a side view readily differentiates *C. voluta* from all other recorded North American charophyte oogonia, but these characters are closely paralleled in the descriptions of several European species. *C. inconspicua* Unger from the Tertiary of Europe possesses cellular ridges. It is possible that some individuals of *C. voluta* might be found on which the ridges are cellular in position, but fossil charophyte oogonia ordinarily represent matured "fruits" and none of the three specimens examined approached the calcification stage of cellular ridges. *C. jaccardi* Heer from the Jurassic of Europe is larger than *C. voluta* and has only six spirals visible in a side view; *C. petrolei* Andreae from the Tertiary of France is oval and has eight spirals visible in a lateral view; and *C. subglobosa* Groves from the Tertiary of

England is globose-ellipsoid to nearly spherical in shape.

Occurrence.—A light-green shale member in the lower part of the Morrison formation, about 18 miles northwest of Rawlins, Wyoming.

Types.—Holotype and paratypes, Univ. Missouri, 31011–5 and 31013–5.

Genus ACLISTOCHARA Peck, n. gen.

Charophyte oogonia with five sinistrally spiralled units that ascend to a truncated summit where they terminate without meeting in the center, leaving a conspicuous opening into the interior of each oogonium. The name is derived from ἄ-κλειστος, not shut.

Remarks.—Among the Morrison charophyte oogonia there occurs a considerable number of individuals with summit truncations, to which the spiral units ascend and terminate without meeting in the center, as they meet on specimens belonging to the genus *Chara*. This summit truncation is a constant character on well-preserved specimens and is considered a structural variation worthy of generic rank.

Although a comparatively large number of specific names have been proposed for sinistrally spiralled charophyte oogonia, many of the species have been defined incidentally in the treatment of a flora or fauna composed largely of groups other than Charophyta, and the *Chara* have been inadequately described and poorly illustrated. For that reason it is impossible to determine, in many cases, whether the spirals meet at the center of the summit or whether they terminate at a summit truncation.

A notable exception to this is found in Heer's (1855) work on the Tertiary flora of Switzerland in which he described several charophyte oogonia. One of these species, *Chara bernoullii* Unger, shows an unquestioned truncated apex which Groves (1933, p. 12) explains as "being probably due to this part (the apex) being imperfectly preserved, as very frequently happens with the fossil fruits." Groves (1925) has also noted that the upper part of the "lime-shell" is the last part to calcify and thus is weaker and more likely to be broken than other parts of the oogonium. Many of the fossil oogonia are broken and the apex is the part that is ordinarily missing. But a charophyte oogonium from which the apex has been broken has a very rough, irregular margin along the edges of the spirals that is not likely to be confused with the smooth truncation present on specimens of *Aclistochara*, in which the

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EXPLANATION OF PLATE 14

(All specimens enlarged 50 diameters)

FIGS. *1–4—Aclistochara latitruncata* Peck, n. sp. *1, 4*, Lateral and basal views of syntype. *2, 3*, Summit and lateral views of syntype. (p. 89)

5–7—Aclistochara oligospirata Peck, n. sp. Summit, lateral and basal views of syntype. (p. 89)

8–11—Aclistochara bransoni Peck, n. sp. *8, 9*, Lateral and summit views of holotype from 18 miles northwest of Rawlins, Wyoming. *10*, Lateral view of paratype from near Mayoworth, Wyoming. *11*, Basal view of paratype from 18 miles northwest of Rawlins, Wyoming. (p. 87)

12–15—Aclistochara jonesi Peck, n. sp. *12*, Lateral view of large syntype. *13–15*, Summit, lateral, and basal views of syntype. (p. 88)

16–19—Chara voluta Peck, n. sp. *16, 18, 19*, Basal, summit, and lateral views of holotype. *17*, Lateral view of paratype. (p. 85)

20–23—Aclistochara lata Peck, n. sp. *20, 22*, Summit and lateral views of syntype. *21, 23*, Basal and lateral views of syntype. (p. 88)

24, 25—Aclistochara elongata Peck, n. sp. Summit and lateral views of syntype. (p. 89)

26–29—Aclistochara obovata Peck, n. sp. *26, 27*, Summit and lateral views of syntype. *28, 29*, Basal and lateral views of syntype. (p. 88)

30–33—Chara verticillata Peck, n. sp. *30*, Summit view of syntype. *31*, Lateral view of small syntype. *32, 33*, Basal and lateral views of syntype. (p. 84)

Peck, Morrison Charophyta

UNIV. OF MICH.

calcite filling of the enveloping cells failed to reach the center of the summit. The "lime-shell" of a charophyte oogonium is secreted within the spiral enveloping cells as five long, independent units. According to Reid and Groves (1921, p. 182), at maturity the lateral walls of the enveloping cells break down and the five long units coalesce to form a fairly strong protective covering. But, as also noted by Reid and Groves (1921, p. 182) and verified by my own observations, the spiral units separate most readily along their lateral edges. When the units are broken they break across the spirals, at right angles to the lengths, not diagonally, thus producing the crenulate edge commonly noted.

In so far as I have been able to determine, the summit truncation is not present on modern charophyte oogonia. It is not possible to determine whether the enveloping cells actually terminated at the edge of the truncation and the summit opening was covered by coronula cells that persisted until after the oospore was fertilized, or the enveloping cells extended to the center and calcite was secreted only up to this truncation. In either case the summit truncation is seemingly a constant character and is of taxonomic value. Two specimens possess a small protuberance that is continuous with the calcite filling of the oogonium, arising in the center of the summit opening. One of these protuberances is marked on the sides by five shallow concavities. It is difficult to visualize how this projection could have been formed unless the coronula cells were retained until the interior was filled with calcite, after the escape of the oogonium contents. This would be impossible if the coronula cells did not calcify in part. It is probable that future work will disclose specimens of *Aclistochara* with the coronula cells in place.

Species of charophyte oogonia that should be referred to *Aclistochara* are as follows: *Chara bernoullii* Unger, Tertiary, Germany (Heer, 1855, p. 26, pl. 4, fig. 6); (?)*Chara granulifera* Heer, Tertiary, Switzerland (Heer, 1855, p. 27, pl. 4, fig. 8); *Gyrogonites moreyi* Peck, Pennsylvanian, Missouri (Peck, 1934, p. 50, figs. 1–3, 5, 6).

Genotype.—*Aclistochara bransoni* Peck, n. sp.

ACLISTOCHARA BRANSONI Peck, n. sp.
Plate 14, figures 8–11

Oogonia small, averaging about 0.4 mm. in length and 0.39 mm. in width, spheroidal in shape, with obtusely rounded bases and deeply truncate summits. Spiral ridges narrow and prominent, intercellular in position, and separated by comparatively broad and deep cellular furrows. The spirals complete about one and one-half turns and cross the equator of the oogonium at an angle of about 14 degrees. Summit opening comparatively large, equaling almost one-third the diameter of the oogonium. Seven or eight spirals visible in a lateral view.

Remarks.—This description is based on five well-preserved specimens. One of these, the holotype, possesses an extraordinarily well-preserved summit area. The calcite filling of the oogonium projects through the summit opening and is indented at the upper ends of the cellular furrows by five small concavities (pl. 14, fig. 9) that probably mark the location of coronula cells. The concavities are shown in less detail on other species referred to *Aclistochara*, but the specimens are so small that it is very difficult to free the summit area of extraneous material.

This species is named in honor of Dr. C. C. Branson, who kindly made his collection of Morrison charophyte oogonia available to me for study.

Occurrence.—A light-green shale member in the lower part of the Morrison formation about 18 miles northwest of Rawlins, Wyoming, and near the middle of the Morrison formation about 3 miles south of Mayoworth, Wyoming.

Types.—Holotype and paratypes Univ. Missouri, 31012–1, 31012–2, and 31012–3.

ACLISTOCHARA OBOVATA Peck, n. sp.

Plate 14, figures 26–29

Oogonia of medium size, the syntypes measuring 0.5 mm. in height and 0.4 mm. in width, obovoid in shape with a pointed, somewhat projecting base and a truncate summit. Spiral ridges intercellular in position, narrow, sharp, and separated by broad, shallow cellular furrows. The spirals make approximately two complete turns, cross the equator at an angle of 8 degrees or less, and terminate at the edge of a summit opening which is about 0.1 mm. in diameter. Eleven spirals are visible in a lateral view.

Remarks.—This description is based on two syntypes, both well preserved, but one slightly flattened, evidently a result of compaction of the enclosing shales. Although the ridges are intercellular in position on both syntypes the cellular furrows are very shallow, indicating almost complete calcification of the enveloping cells. A larger number of representatives of the species would probably show some individuals with the spiral ridges cellular in position.

The obovoid shape and large number of spirals visible in a lateral view readily differentiates *A. obovata* from other species of the genus.

Occurrence.—A light-green shale member in the lower part of the Morrison formation about 18 miles northwest of Rawlins, Wyoming.

Syntypes.—Univ. Missouri, 31012–4

ACLISTOCHARA JONESI Peck, n. sp.

Plate 14, figures 12–15

Oogonia small, averaging about 0.5 mm. in height and 0.35 mm. in width, subcylindrical in shape with an obtusely rounded base and truncate summit. Spiral ridges cellular in position, broad, gently convex, and separated by narrow, shallow intercellular furrows. The spirals complete almost two turns, cross the equator of the oogonium at an angle of about 11 degrees, and terminate at the edge of a summit opening which is about 0.1 mm. in diameter. Nine spirals are visible in a side view.

Remarks.—This description is based on five well preserved syntypes, all of which are remarkably uniform in size, shape, number of spirals visible in a lateral view, and in possessing cellular ridges and a low equatorial angle. *A. bransoni* has an equatorial angle of 16 degrees, is wider in relation to length than *A. jonesi*, and has a flattened base.

Named in honor of Mr. Carl Jones, a graduate student at the University of Missouri, who collected part of the charophyte oogonia from the Morrison.

Occurrence.—A light-green shale member in the lower part of the Morrison formation, approximately 18 miles northwest of Rawlins, Wyoming.

Syntypes.—Univ. Missouri, 31012–5.

ACLISTOCHARA LATA Peck, n. sp.

Plate 14, figures 20–23

Oogonia small, the syntypes measuring 0.4 mm. in both width and height, subglobose in shape with a slightly flattened base and a deeply truncate summit. Spiral ridges intercellular in position, very small and sharp, the intervening cellular furrows almost completely filled and appear as wide, shallow, flattened troughs. The spirals complete almost two turns around the oogonium, cross the equator at an angle of about 6 degrees, and terminate at the edge of a summit opening which is about 0.1 mm. in diameter. Nine or ten spirals visible in a lateral view.

Remarks.—This description is based on two well-preserved syntypes. These specimens are almost exact duplicates, but on one the cellular furrows are more nearly filled and the intercellular ridges are less prominent. Both specimens are slightly asymmetrical at the base, a feature probably caused by compaction of the shale in which they were imbedded.

The most outstanding character of *A. lata*, is the length-width ratio. As the syntypes are almost perfectly circular in

outline at the equator, the unusual width has not resulted from crushing.

Occurrence.—A light-green shale member in the lower part of the Morrison formation about 18 miles northwest of Rawlins, Wyoming.

Syntypes.—Univ. Missouri, 31013–1.

ACLISTOCHARA OLIGOSPIRATA Peck, n. sp.
Plate 14, figures 5–7

Oogonium very small, the syntypes averaging 0.38 mm. in height and 0.3 mm. in width, subcylindrical, with the sides diverging for a short distance beyond a slightly flattened base and then ascending parallel to each other to near the summit where they converge slightly to a deep truncation. Spiral ridges prominent, intercellular in position, making one complete turn and crossing the equator of the oogonium at an angle of 22 degrees. Five spirals visible in a side view.

Remarks.—This description is based on two syntypes that differ markedly from the associated oogonia in size and number of spirals visible in a side view.

Occurrence.—A light-green shale member in the lower part of the Morrison formation about 18 miles northwest of Rawlins, Wyoming.

Syntypes.—Univ. Missouri, 31013–3.

ACLISTOCHARA ELONGATA Peck, n. sp.
Plate 14, figures 24, 25

Oogonia small, the syntypes averaging 0.53 mm. in height and 0.35 mm. in width, subcylindrical in shape, the sides expanding gradually from the slightly flattened base to the greatest diameter at about mid-height, and then gradually converging to a deeply truncate summit. Spiral ridges fairly low and wide, intercellular in position, and separated by shallow cellular furrows of unusual width. The spirals complete approximately one and one-half turns and cross the equator at an angle of about 20 degrees. Seven or eight spirals visible in a lateral view.

Remarks.—This description is based on two well-preserved syntypes. They are distinctive in the length-width ratio, which gives them an elongate, cylindrical appearance; in the high angle made by the spirals with the equatorial plane; and the unusual width of the cellular furrows. *A. oligospirata* Peck is subcylindrical in shape, is much smaller than *A. elongata*, and has wide cellular furrows that cross the equatorial plane at a high angle. Ordinarily some variation in size is expected within a species but most fossil charophyte "lime-shells" represent mature oogonia. It is only in the mature oogonium that sufficient calcium carbonate is secreted to preserve the unit as such. For that reason a marked variation in size, such as is presented by *A. oligospirata* and *A. elongata*, is sufficient for specific distinction.

Occurrence.—A light-green shale member in the lower part of the Morrison formation, approximately 18 miles northwest of Rawlins, Wyoming.

Syntypes.—Univ. Missouri, 31013–2.

ACLISTOCHARA LATITRUNCATA Peck, n. sp.
Plate 14, figures 1–4

Oogonia larger than average, measuring 0.5 mm. in width and height, subconoidal, the sides of the lower half rising in a rapidly expanding cone to slightly above mid-height and thence contracting slowly to a deeply truncate summit. Spiral ridges cellular or intercellular in position. If cellular, the broad, gently convex ridges are separated by narrow intercellular furrows—if intercellular, the sharp, narrow ridges are separated by broad shallow cellular furrows. The spirals complete approximately one and one-half turns and cross the equator of the oogonium at an angle of from 12 degrees to 18 degrees. Eight or nine spirals visible in a side view.

Remarks.—This description is based on three syntypes, two of which have cellular ridges, and one intercellular ridges. The position of the spiral ridges depends on the degree of calcification of the enveloping cells, a variation such as may occur among the oogonia of any species of Charophyta.

The subconoidal shape and deep summit truncation readily differentiate *A. latitruncata* from other species of the genus.

Occurrence.—Near the middle of the Morrison formation about 3 miles south of Mayoworth, Wyoming.

Syntypes.—Univ. Missouri, 31013–4.

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CRETACEOUS AND TERTIARY FORAMINIFERA FROM SOUTHERN SANTA CLARA PROVINCE, CUBA

A. A. THIADENS

ABSTRACT

Foraminiferal faunas of Upper Cretaceous, upper Eocene, Oligocene, and Miocene age from southern Santa Clara province, Cuba, are described. *Lepidorbitoides rutteni*, *L. rutteni* var. *armata*, *L. palmeri*, and *L. macgillavryi* are new forms from Upper Cretaceous beds. A doubtful species belonging to the Peneroplidae is discussed. Species that until now have been considered to be of upper Eocene age only and other species of Oligocene age only, have been found together. *Lepidocyclina tschoppi* is a new species of the transitional beds between upper Eocene and Oligocene. The synonymy of *Lepidocyclina favosa* and *L. formosa* is discussed. Several species that are combined by some authors are here separated. *Lepidocyclina* (*Eulepidina*) *petri* is a new species of Oligocene age.

The material here described was collected in March and April, 1933, during a geological survey by some geologists from Utrecht with Prof. L. M. R. Rutten. The geological results will be published later; given

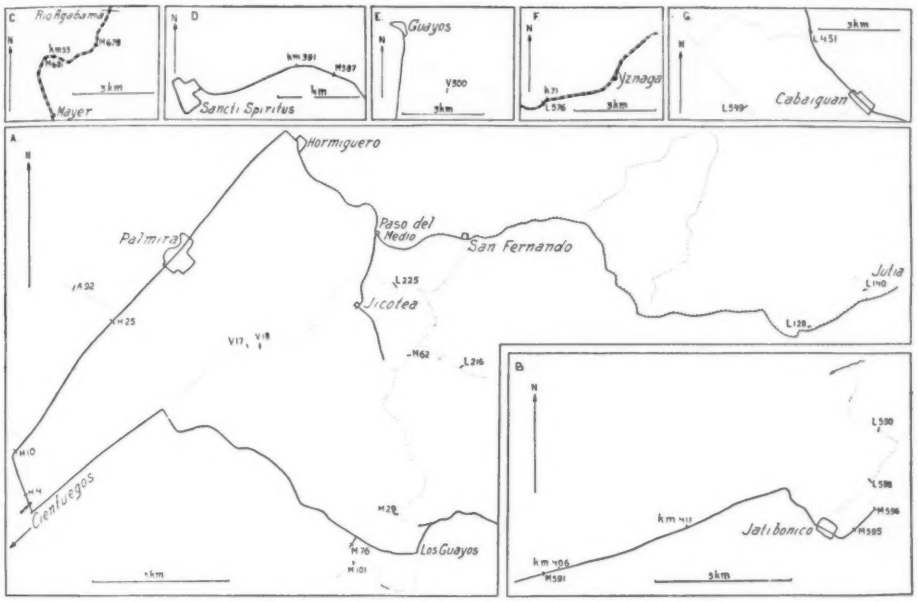

FIG. 1—A—Sketch map of the neighborhood of Cienfuegos and San Fernando.
B—Sketch map of the neighborhood of Jatibonico.
C, F—Sketch maps of parts of the railway from Placetas to Trinidad through the Sierra de Trinidad.
D—Sketch map of the Carretera Central near Sancti Spiritus.
E—Sketch map showing V 300 near Guayos on the Carretera Central.
G—Sketch map from the neighborhood of Cabaiguan.

here are notes on the Foraminifera, which range in age from Upper Cretaceous to Miocene. They were obtained from weathered limestones and white marls at localities indicated on accompanying sketch maps (fig. 1). Locs. L 229 and L 232, not shown on the maps, are situated respectively on the east bank of Ramirez River near its mouth, and at Punto Barril on Cienfuegos Bay. The letters L, M, H, and V, preceding the field numbers, indicate respectively the collectors L. Rutten, M. Rutten, H. Mac Gillavry, and L. Vermunt. All the specimens here described are in the Mineralogical-Geological Institute of Utrecht University, Holland. The numbers preceded by D indicate thin-sections in this Institute.

The faunas found at the different localities, their geological ages, and the mode of occurrence of the different species are indicated on the five accompanying tables.

Upper Cretaceous Foraminifera from Santa Clara province, Cuba

Localities	M 29	M 62	M 76	M 101	L 128	L 140	L 225	V 300
(?) *Archaias rutteni* (Palmer)	—	—	—	—	r	—	—	—
Camerina vermunti Thiadens, n. sp.	—	—	—	—	a	—	—	c
Camerina sp. C	—	—	—	—	c	—	—	—
Orbitoides browni (Ellis)	c	c	c	c	—	r	a	c
Orbitoides palmeri Gravell	r	—	—	—	r	—	c	—
Orbitoides apiculata Schlumberger	—	—	—	r	—	—	r	—
Lepidorbitoides rutteni Thiadens, n. sp.	—	—	—	—	a	c	—	—
Lepidorbitoides rutteni var. *armata* Thiadens, n. var.	—	—	—	—	a	—	—	—
Lepidorbitoides macgillavryi Thiadens, n. sp.	—	—	—	—	a	r	—	—
Lepidorbitoides palmeri Thiadens, n. sp.	—	—	—	—	a	—	—	—

r = rare; c = common; a = abundant.

Upper Eocene Foraminifera from Santa Clara province, Cuba

Localities	M 678	M 681	L 216	L 431	L 549	V 17
Dictyoconus fontabellensis Vaughan	—	c	c	c	c	—
Camerina petri M. Rutten	—	—	—	—	—	c
Camerina sp., cf. C. *parvula* Cushman	r	—	—	—	—	—
Camerina sp. D	a	—	—	—	—	—
Lepidocyclina mortoni Cushman	c	c	—	—	—	r
Lepidocyclina pustolosa H. Douvillé	—	a	—	—	—	—
Lepidocyclina trinitatis H. Douvillé	—	—	—	—	—	c
Lepidocyclina sp.	a	—	—	—	—	—
Helicolepidina spiralis Tobler	a	c	—	—	—	c
Discocyclina blumenthali Gorter and Van der Vlerk	c	—	—	—	—	—
Discocyclina vermunti Rutten	c	r	—	—	—	r
Discocyclina sp	—	—	c	—	c	—

r = rare; c = common; a = abundant.

Foraminifera of transitional beds between upper Eocene and Oligocene from Santa Clara province, Cuba

Localities	L 588	L 590
Lepidocyclina maracaibensis Hodson	c	—
Lepidocyclina mortoni Cushman	a	c
(?) *Lepidocyclina supera* (Conrad)	c	—
Lepidocyclina tschoppi Thiadens, n. sp.	c	—
Lepidocyclina weeksi Hodson	r	—
Lepidocyclina formosa Schlumberger	a	c
Helicolepidina spiralis Tobler	c	—

r = rare; c = common; a = abundant.

Oligocene Foraminifera from Santa Clara province, Cuba

Localities	H 25	L 229	M 587	M 596	H 4	H 10
Camerina sp. A	—	r	—	—	—	—
Camerina sp. B	—	r	—	—	r	c
Planularia sp.	—	r	—	—	—	—
Lepidocyclina formosa Schlumberger	c	a	c	c	—	—
Lepidocyclina undosa Cushman	—	a	—	—	—	—
Lepidocyclina marginata (Michelotti)	—	a	—	—	—	—
Lepidocyclina petri Thiadens, n. sp.	—	—	a	—	—	—

r = rare; c = common; a = abundant.

Oligocene-Miocene Foraminifera from Santa Clara province, Cuba

Localities	M 591	M 595	L 232
Archaias adunca (Fichtel and Moll)	r	a	a
Amphisorus matleyi Vaughan	c	a	—
Miogypsina hawkinsi Hodson	—	a	a

r = rare; c = common; a = abundant.

Among results of this study the following may be noted: (1) The occurrence of *Camerina* in Upper Cretaceous rocks of Cuba is remarkable in my opinion. The species are all very small and are ornamented with one or several knobs or are smooth. (2) Eulepidine lepidocyclinas, which until now have been thought to occur only in Oligocene beds of the Antillean region, are here reported in association with typical Eocene forms, such as *Helicolepidina spiralis* and *Lepidocyclina mortoni*. (3) Question as to existence of truly generic differences between *Sorites* and *Amphisorus* has been raised by my study of the common Miocene form *Amphisorus*. (4) A species which closely resembles *Archaias adunca* has been found in Cretaceous sediments. (5) Gigantic and twinned nucleoconchs have been found in specimens of *Orbitoides browni* and *Lepidorbitoides rutteni*.

SYSTEMATIC DESCRIPTIONS

Genus PLANULARIA Defrance, 1824

PLANULARIA sp.

Plate 16, figures 2, 3

Test of medium size, flat, bilaterally symmetrical, semicircular, involute, composed of one and a half to two whorls that increase rapidly in width, the last containing 18 chambers; sutures, marginal cord and central knob of white shell material, sutures strongly curved backward in the first whorl, straight in the last whorl except on the periphery where they are curved backward; measurements of the last chamber, radial 0.6 mm., tangential 3.3 mm. Embryonal apparatus consists of one large subspherical chamber measuring 520μ. Diameter of the test, 3.75 mm. $\times$2.55 mm.; thickness 0.55 mm.

Occurrence.—Only two specimens have been found. These are from Loc. L229, Oligocene, Santa Clara province, Cuba. Figured specimens, Min.-Geol. Inst., Utrecht, D15972, D15973.

Genus DICTYOCONUS Blanckenhorn, 1900

DICTYOCONUS FONTABELLENSIS (Vaughan)

Plate 16, figure 13

Cushmania fontabellensis VAUGHAN, *1928*, Jour. Paleontology, vol. 1, p. 282, pl. 44, fig. 3.

Dictyoconus fontabellensis (VAUGHAN), *1932*, Jour. Paleontology, vol. 6, pp. 97, 98, pl. 14, figs. 6, 7.

The base of this species is flat, or in some cases slightly convex at the periphery. Apertures at the base large (pl. 16, fig. 13). Thickness of the basal chamber walls is about 70μ. Marginal trough divided into two to four cellules. Platforms in center near the base separated 140μ–170μ and at the periphery 180μ. Height, 1.1 to 1.6 mm., diameter of base 1.6 to 2.0 mm.

Occurrence.—Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15464, D15495.

Genus CAMERINA Bruguière, 1792

CAMERINA VERMUNTI Thiadens, n. sp.

Plate 16, figures 1, 11, 12; Text-figures 2C, 3A, E

Test small, circular, symmetrical or asymmetrical with regard to the equatorial plane, involute; composed of three to three and one-half whorls that increase regularly in width, the last containing 19 to 23 chambers; surface smooth, with or without a central knob, sometimes striate; sutures radiate. Embryonic apparatus consists of one spherical chamber, 60μ to 90μ. Septa straight, radiating, rather thick, clearly double. Chambers trapezoid, radial diameter twice the tangential (in last whorl 300μ $\times$150μ). Aperture unknown. The vertical section is difficult to obtain because of recrystallization and secondary filling of the test. A median groove occurs on the edge (text-fig. 3A, E), as found also by Vermunt in material of Pinar del Rio. Only three of fifteen thin sections of the loose material show it, but thin sections of solid rock show it very well. The marginal wall is generally damaged and recrystal-

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EXPLANATION OF PLATE 15

(All specimens from Santa Clara province, Cuba)

FIGS. *1*, *7*—(?)*Archaias*, (?)*Meandropsina*, (?)*Fallotia*, or another genus of the Peneroplidae. *1*, External view, $\times$16.7. *7*, Horizontal section $\times$23.6. Upper Cretaceous. (p. 98)

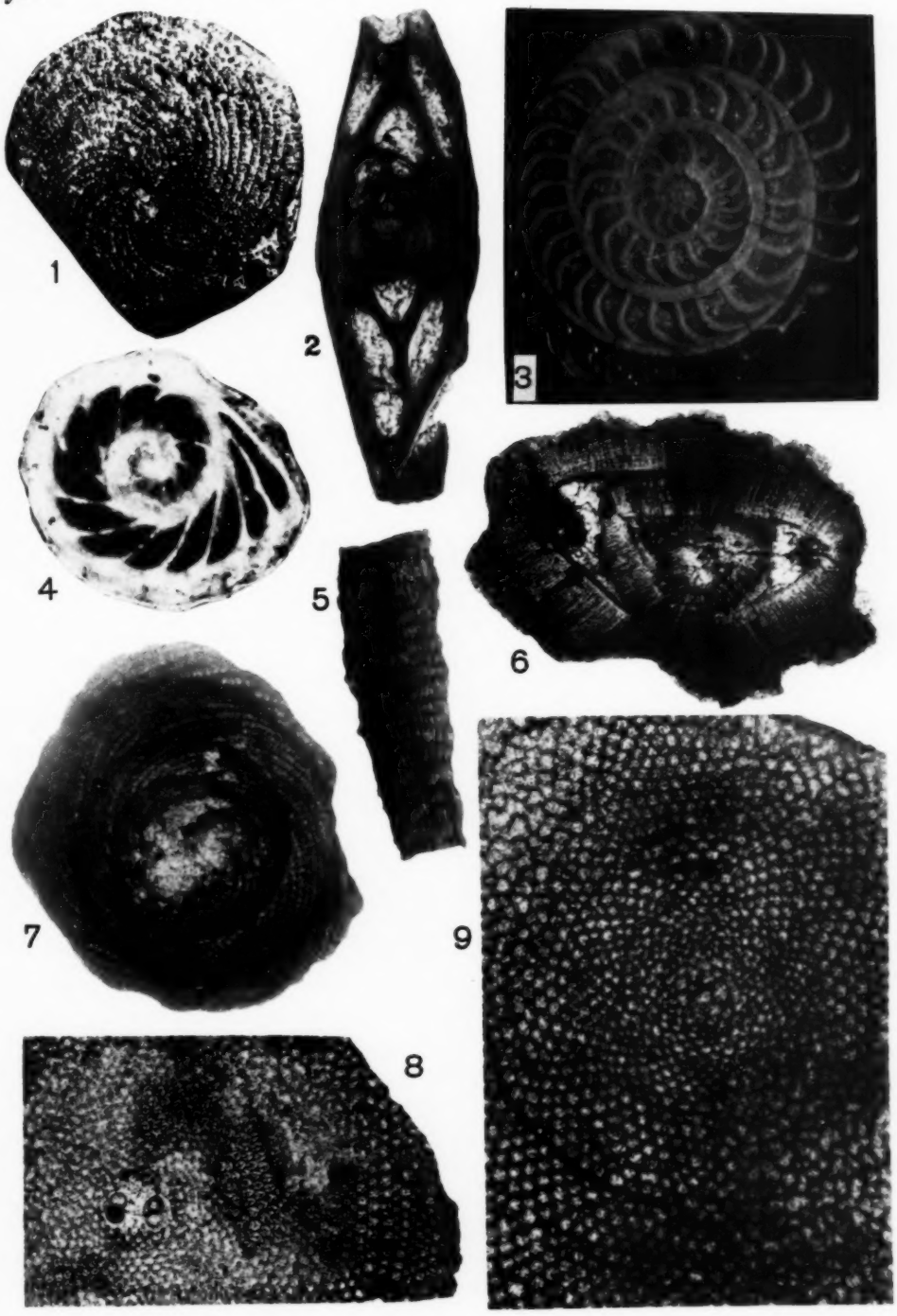
2—*Camerina* sp. A. Vertical section, $\times$31. Oligocene. (p. 95)

3—*Camerina* sp. B. Horizontal section, $\times$18. Oligocene. (p. 95)

4—*Camerina* sp. C. Horizontal section, $\times$19.5. Upper Cretaceous. (p. 95)

5, *8*, *9*—*Lepidorbitoides* (*Lepidorbitoides*) *rutteni* Thiadens, n.sp. *5*, Vertical section, $\times$37. *8*, Horizontal section showing a twinned nucleoconch, $\times$24.5. *9*, Horizontal section, $\times$32. Upper Cretaceous. (p. 100)

6—*Camerina* sp. cf. *C. parvula* (Cushman). Vertical section, $\times$48. Upper Eocene. (p. 95)



Thiadens, Cretaceous and Tertiary Foraminifera

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lized. Measurements and number of whorls are indicated in text-fig. 2C.

Remarks.—The straight radiating septa and the median groove on the edge are characteristic for this species. It differs from *C. dickersoni* Palmer in the greater thickness of its test and the form of its septa. *C. cubensis* Palmer, which typically is ornamented by many knobs, is also quite different from *C. vermunti*. The species is named in honor of Mr. L. W. J. Vermunt.

Occurrence.—Upper Cretaceous, Loc. L 128 (type locality, see sketch map A) near Abra de Castillon, 13 km. east-southeast of San Fernando, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht., D15917–D15952.

CAMERINA sp. cf. C. PARVULA (Cushman)

Plate 15, figure 6; Plate 16, figure 8

Nummulites parvula CUSHMAN, *1919*, Geol. Pal. West Indies, Contr., p. 51, figs. 3–6.
Camerina sp. cf. *C. parvula* GRAVELL, *1933*, Smithsonian Misc. Coll., vol. 89, pp. 14, 15, pl. 1, fig. 6.

Tests small, thick, lenticular, center marked by clear shell material which may be raised sometimes forming a knob; composed of three whorls, the last containing about 19 chambers measuring 370μ (radial) $\times$180μ (tangential); walls strongly curved. Surface striate. Embryonic apparatus consists of one spherical chamber 148μ in diameter. Vertical section shows one large central pillar and thick walls (190μ).

Remarks.—This species differs from *C. parvula* only in the number of chambers.

Occurrence.—Upper Eocene, Santa Clara province, Cuba. Figured specimens Min.-Geol. Inst., Univ. Utrecht, D15898–D15903.

CAMERINA sp. A

Plate 15, figure 2

Test small (diameter, 2.7 mm., thickness, 0.74 mm.), lenticular, involute, composed of three whorls, surface smoth, no pillars; only the vertical section known. This form is characterized by a large median keel, measuring 260μ in the last whorl. The initial chamber is large and subspherical, 0.3 mm. in diameter.

Remark.—Only one specimen at hand.

Occurrence.—Oligocene, Santa Clara province, Cuba. Figured specimen, Min.-Geol. Inst., Univ. Utrecht, D15894.

CAMERINA sp. B

Plate 15, figure 3; Text-figures 3B, D

Test small (diameter, 2.6 mm., thickness, 0.9 mm.), lenticular, involute, composed of about four to five whorls, the last one containing 28 septa; surface smooth; sutures radiating from center, bending backward on periphery. The form of the chambers is very characteristic, the septa showing a marked backward inclination of 110 to 140 degrees at three-fourths of the height of the chamber; septa from the outer side of the inner wall come down at an angle of 90 degrees, reaching the inner side of the outer wall with an angle of 20 to 50 degrees. Chambers twice as high as long. Septa rather thick and clearly double. Initial chamber subspherical.

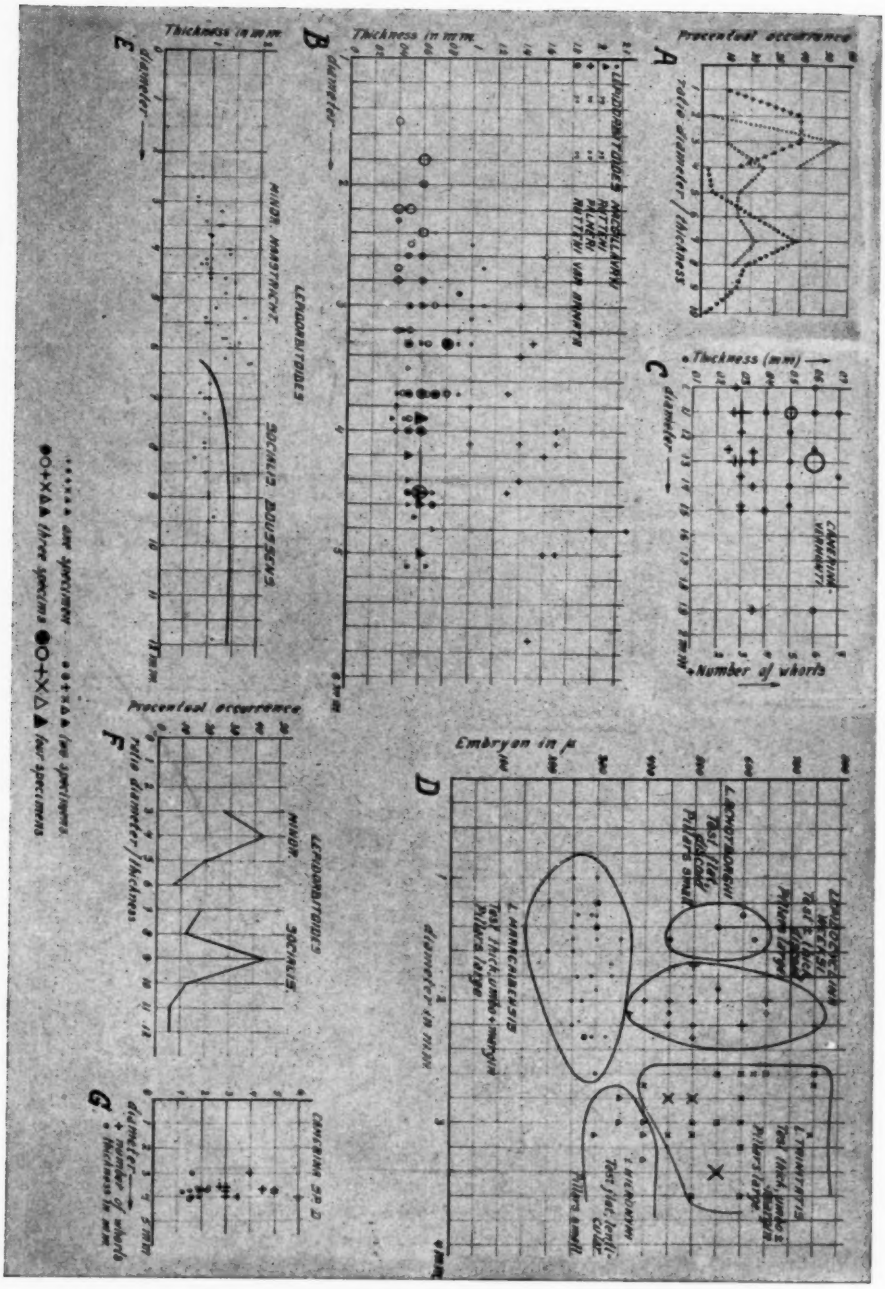
Remarks.—Although this is probably a new species, it has not been named because the material, consisting of only 14 specimens, is too poor for adequate specific characterization.

Occurrence.—Oligocene, Locs. L 229, H 4, and H 10 (map A), Santa Clara province, Cuba. Figured specimens, Min.-Geol. Inst., Univ. Utrecht, D15895–D15897, D16065–D16076.

(?)CAMERINA sp. C

Plate 15, figure 4; Plate 16, figures 7, 10

Test small, thick, umbonate, with indistinct margin, completely involute, with two whorls that increase rapidly in height, the last containing 13 chambers; surface smooth. Septa straight, directed strongly backward, rather thick, double. Vertical sections show that the walls are thick and lamellar. The last chamber measures 740μ (radial) $\times$180μ (tangential). The last chamber of the first whorl measures 300μ (radial) $\times$220μ (tangential). Diameter of test, 1.6 to 2.8 mm. Thickness, 0.7 to 1.5 mm.


A
Percentual occurrence
ratio diameter/thickness
B
Thickness in mm
diameter
LEPIDOCYCLINA (NEPHROLEPIDINA) MORGANI (LEMOINE & DOUVILLÉ) VAR. JAVANA (VERBEEK)
C
Thickness (mm)
diameter
CAMERINA VARIANS
Number of whorls
D
Embryon in μ
diameter in mm
L. (NEPHROLEPIDINA) MORGANI VAR. JAVANA

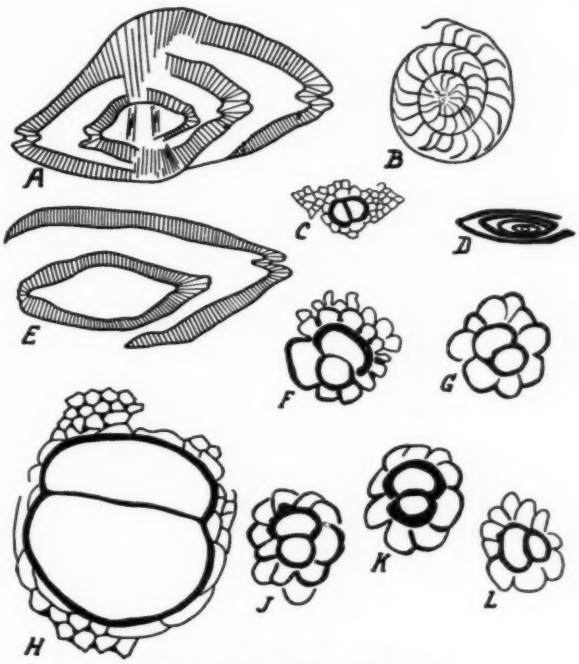
Remarks.—I refer this form to the genus *Camerina* because of its thickness and its highly involute character.[1]

Occurrence.—Upper Cretaceous, Loc. L 128 (map A), Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15885–D15893.

[1] According to information from Dr. T. Wayland Vaughan this form is identical with *Operculinoides antiguensis* Vaughan and Cole (U. S. Nat. Mus., Proc., in press).

CAMERINA sp. D
Text-figure 2G

Test of medium size, lenticular, completely involute, composed of four to six whorls with 24 chambers in the fourth whorl, chambers strongly curved backward, shorter tangentially than radially, in the last whorl measuring 0.37 mm. (tangential) ×0.6 mm. (radial); surface smooth, sutures of clear shell material not always visible. Lateral and vertical sections show a large central column.



EXPLANATION OF TEXT-FIGURE 3

(All specimens from Santa Clara province, Cuba.)

A, E—Camerina vermunti Thiadens, n.sp. *A*, Vertical section, ×51. *E*, Vertical section, ×58. Upper Cretaceous. (p. 94)

B, D—Camerina sp. B. *B*, Horizontal section, ×9. *D*, Vertical section, ×9. Oligocene. (p. 95)

C—Lepidocyclina (*Lepidocyclina*) *maracaibensis* Hodson. Horizontal section, ×21. Transition beds, upper Eocene-Oligocene. (p. 103)

F, J—Lepidorbitoides (*Lepidorbitoides*) *rutteni* Thiadens n.sp. *F*, Horizontal section, ×45. *J*, Horizontal section, ×52. Upper Cretaceous. (p. 100)

G, L—Lepidorbitoides (*Lepidorbitoides*) *rutteni* var. *armata* Thiadens., n. var. *G*, Horizontal section, ×50. *L*, Horizontal section, ×47. Upper Cretaceous. (p. 101)

H—Lepidocyclina (*Lepidocyclina*) *tschoppi* Thiadens, n.sp. Horizontal section, ×23. Transition beds, upper Eocene-Oligocene. (p. 103)

K—Lepidorbitoides (*Lepidorbitoides*) *macgillavryi* Thiadens, n.sp. Horizontal section, ×52. Upper Cretaceous. (p. 101)

Walls and marginal cord thick. Embryon consists of one subspherical chamber in macrospheric forms. Microspheric forms also have been found. Measurements of test, diameter 3 to 4 mm.; thickness 1.6 mm. to 2.3 mm.

Remarks.—This species is related to *C. petri* M. Rutten, but differs in the form of its chambers.

Occurrence.—Upper Eocene, Loc. M 678 (map C), Santa Clara province, Cuba. Figured specimens, Min.-Geol. Inst., Univ. Utrecht, D15904–D15916.

Family PENEROPLIDAE (?)

Genus ARCHAIAS, FALLOTIA, MEANDROPSINA, or another genus of this family

Plate 15, figures 1, 7

(?)*Meandropsina rutteni* PALMER, *1934*, Soc. cubana hist. nat., Mem., vol. 8, no. 4, pp. 252–255, pl. 12, fig. 2, text-figs. 15, 15A.

The five specimens here discussed probably belong to the Peneroplidae but it is not proved that they are porcellaneous. Test small, lenticular, circular, planispiral, bilaterally symmetrical, completely involute. The form and arrangement of the chambers are the same as in *Archaias*, the chambers being divided into chamberlets by delicate partitions, but whether the partitions join the concave face of the succeeding chambers is not determinable. Annular chambers have not been seen.

Measurements of specimens

Diameter (mm.)	2.4	2.6	1.8	2.25	1.85
Thickness (mm.)	0.4	0.6	0.5	0.6	0.6
Number of whorls	?	?	?	?	3.5
Chambers in the last whorl	29	?	?	?	26

Undoubtedly this is the same form as Palmer (1934) describes, as follows:

Test very thin-walled and delicate, porcellaneous?; small in size seldom exceeding 2.2 mm. in diameter with a thickness of 1 mm.; oval in side view, bilaterally symmetrical, completely involute, compressed. Periphery narrow and rounded. Umbonal region slightly depressed. Surface smooth and without ornamentation. Suture lines very broadly curved and slightly depressed, 20 to 25 narrow chambers in the final whorl subdivided by numerous (more than 60 in the last formed chambers) delicate partitions into chamberlets. The partitions of the chambers are in two series, a primary series which appears to join the concave face of the succeeding septum and a secondary series extending approximately half way to the contiguous septum. Apertures not discernible. Meandering superficial layers absent. In horizontal section a specimen measuring 2 mm. in diameter and comprising three whorls has a small spherical initial chamber measuring 0.066 mm. The vertical section shows the test to be completely involute.

The generic determination of this form is difficult. Palmer says at the bottom of text-figure 15A that the secondary partitions at the bottom are superficial and do not appear in sections, which is remarkable. If later on it should appear that these secondary partitions really exist, this could well be the basis for establishing a new genus. I am inclined to doubt their existence, however, and to regard these "secondary partitions" as superficial ornamentations. There are several objections to Palmer's reference of this form to *Meandropsina*. (1) The meandering superficial layers, typical of *Meandropsina*, never have been found. Palmer obviates this difficulty by assuming that we have only young forms, as described by Schlumberger (1899). (2) In that case, however, neither Palmer nor I have found adult specimens; although, as Palmer says, fragments are almost invariably present in large collections of the Upper Cretaceous from Cuba. (3) We have to do with forms with complete partitions, as is evident from Palmer's description. With regard to this feature we encounter the following inconsistency. Schlumberger states in the original description of the genotype of *Meandropsina* that the chambers are subdivided into chamberlets by incomplete septa, but his figure (Schlumberger, 1899, pl. 9, fig. 11) undoubtedly shows complete septa in several places. A new description of the type material is needed to determine whether *Meandropsina* has complete or incomplete septa. The same

difficulty occurs in the case of *Fallotia* H. Douvillé, of which I have not seen a horizontal section showing the incomplete septa to which Douvillé (1902, table, p. 305) refers. It seems improper to identify the form here discussed as *Meandropsina* since the typical meandering lateral chambers of this genus are lacking, and since there is no sufficiently unambiguous description of the genotype. Should *Meandropsina* and *Fallotia* have incomplete septa, then our form should be classed with *Archaias*. It strikingly resembles *A. adunca* (Fichtel and Moll), but differs from it in the number of chambers and chamberlets. If *Meandropsina* and *Fallotia* have complete septa, then it is possible that our form belongs to either of them, with preference for *Fallotia* because of the first two objections raised by me above.

Occurrence.—Upper Cretaceous, Loc. L 128 (map A), Santa Clara province, Cuba. Figured specimens, Min.-Geol. Inst., Univ. Utrecht, D16083–D16086.

Genus ORBITOIDES d'Orbigny, 1847

ORBITOIDES PALMERI Gravell

Orbitoides palmeri GRAVELL, *1930*, Jour. Paleontology, vol. 4, pp. 269, 270, pl. 22, figs. 1–10.

Our forms agree well with the description and figures given by Gravell. In some cases the test is biconically symmetrical and almost lenticular.

Occurrence.—Upper Cretaceous, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht. D15516–D15522.

Genus LEPIDORBITOIDES Silvestri, 1909

M. G. Rutten (1935) has shown that *Orbitocyclina* and *Lepidorbitoides* are synonyms, for stolons occur in *Lepidorbitoides minor*. It is possible, as suggested by Tan Sin Hok (1934), that the genotype of *Lepidorbitoides* (*L. socialis*) lacks stolons and, therefore, doubt might be expressed concerning acceptance of this synonymy. M. G. Rutten, however, has recently studied *L. socialis* from Boussens, the type locality of the genotype, and has shown the existence of stolons in this form. These can be seen in Rutten's photographs, one of which is printed here (pl. 19, fig. 9). Vaughan (1936) has found also that *L. socialis* has six stolons to each chamber. The synonymy is thus definitely proved.

Tan Sin Hok (1934) has pointed out in figures by Vaughan and M. Rutten a difference in the arrangement of the peri-embryonal chambers in *L. minima* and *L. minor*, the former having only one and the latter two *Hauptauxiliarkammern*. Whether these features are of generic significance I cannot say. All but one of my specimens studied have two *Hauptauxiliarkammern* (text-figure 3F, G, J, K, L).

It is desirable to discuss the validity of the two European species *L. socialis* and *L. minor*. Schlumberger (1901, 1902) described *Orbitoides socialis* and *O. minor* as two Upper Cretaceous species. Silvestri (1907) created for *O. socialis* the new genus *Lepidorbitoides*. Recognizing the *Lepidorbitoides* character of *O. minor*, H. Douvillé considered this form to be only a variety of *L. socialis* and he named it *Lepidorbitoides socialis* race *minor*. He considered that between *L. socialis* and *L. socialis* race *minor* there is only a difference in dimensions.

In the paleontological collection of the Min.-Geol. Inst., Univ. Utrecht, we have type material of *L. socialis* from the Maastrichtian beds near Boussens (France) and of *L. minor* from the Maastrichtian of Maastricht (Holland), and in addition we have specimens of *L. minor* from the Maastrichtian of La Feza in the Sierra del Cadi, northern Spain (Boissevain, 1934). I have studied this material and have come to the conclusion that various differences that are of specific value distinguish these two forms. These differences are shown in the following table (see also pl. 16, figs. 4, 5, and text-figures 2E, F, for differences in shape).

Comparison of characters of Lepidorbitoides socialis *and* L. minor

Lepidorbitoides socialis	*Lepidorbitoides minor*
Flat; diameter, 6.7 to 11.9 mm., thickness 0.7 to 1.1 mm.	Lenticular; diameter, 2.5 to 6.3 mm., thickness 0.6 to 2.0 mm.
Equatorial chambers hexagonal, radial diameter longer than tangential.	Equatorial chambers never hexagonal, radial diameter as long as tangential, spatulate or ogival.
Lateral chambers 37μ high, higher than their horizontal walls.	Lateral chambers 25μ high, as high as their walls.
Pillars varying little in diameter (110μ to 145μ).	Pillars varying in diameter, thickest in the center (100μ to 180μ).
Embryonic apparatus: first chamber 140μ to 180μ, second chamber 175$\mu\times$240μ to 185$\mu\times$370μ.	Embryonic apparatus: first chamber 148μ, second chamber 148$\mu\times$229μ.
(Occurs in southern France.)	(Occurs in Holland and northern Spain.)

Subgenus LEPIDORBITOIDES
Silvestri, 1909

LEPIDORBITOIDES (LEPIDORBITOIDES) RUTTENI Thiadens, n. sp.

Plate 15, figures 5, 8, 9; Plate 17, figure 5; Plate 19, figure 8; Text-figures 2A, B; 3F, J

Test of medium size, flat, circular, symmetrical and sometimes asymmetrical with regard to the equatorial layer (in the latter case saucer-shaped), discoid, slightly thicker in the center than on the periphery. Surface smooth, reticulate, no pillars. Lateral chambers open, thick-walled, five to nine layers, in vertical section measuring 25$\mu\times$70μ to 50$\mu\times$100μ. Equatorial chambers hexagonal to short-hexagonal and spatulate to truncate, arranged on concentric circles. Measurements 140μ (radial) $\times$110μ (tangential), 95$\mu\times$110μ and 74$\mu\times$74μ. On vertical section the equatorial layer increases in height from 26μ in the center to 90μ on the periphery. Embryonic apparatus of the *Lepidorbitoides*-type, one small subspherical primary chamber followed by a larger reniform second one, together measuring 90$\mu\times$110μ to 260$\mu\times$290μ, average 120$\mu\times$180μ. The two initial chambers are followed by six to ten chambers, gradually diminishing in size, but all larger than the other equatorial chambers, spirally arranged. In one specimen a twinned embryon is found. Measurements of the test: diameter 3

EXPLANATION OF PLATE 16

(All specimens from Santa Clara province, Cuba, except figs. 4 and 5)

FIGS. *1*, *11*, *12*—*Camerina vermunti* Thiadens, n.sp. *1*, External view, $\times$14. *11*, *12*, Both horizontal sections, $\times$20. Upper Cretaceous. (p. 94)

2, *3*—*Planularia* sp. External views, $\times$14.2. Oligocene. (p. 94)

4—*Lepidorbitoides* (*Lepidorbitoides*) *minor* Schlumberger. External view of topotype, $\times$4.27. Maastrichtian beds, Maastricht, Holland. (p. 100)

5—*Lepidorbitoides* (*Lepidorbitoides*) *socialis* (Leymerie). External view of topotype, $\times$4.27. Maastrichtian beds, near Boussens, France. (p. 100)

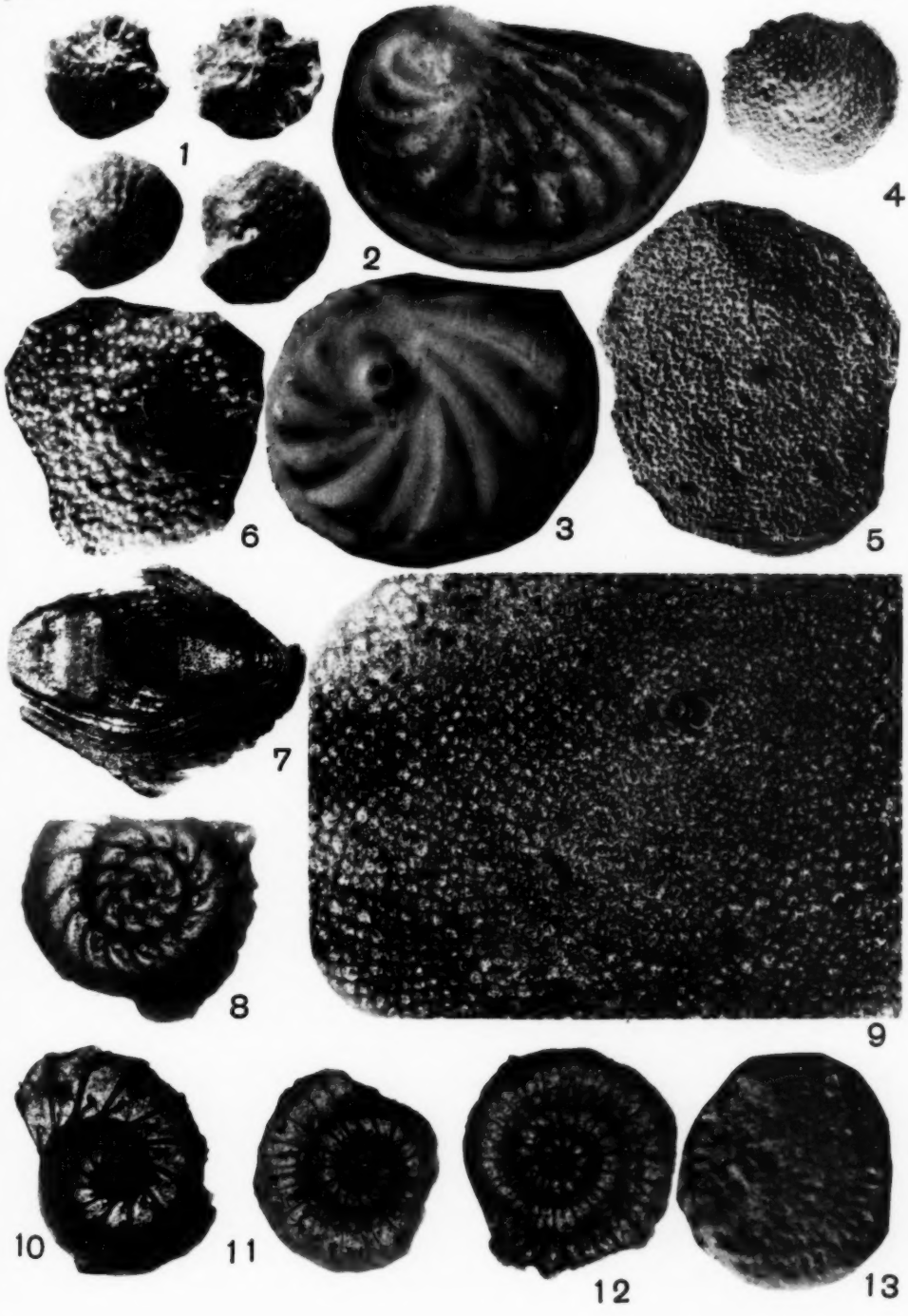
6—*Lepidorbitoides* (*Lepidorbitoides*) *rutteni* var. *armata* Thiadens, n. var. External view, $\times$14. Upper Cretaceous. (p. 101)

7, *10*—*Camerina* sp. C. *7*, Vertical section, $\times$50. *10*, Horizontal section, $\times$22. Upper Cretaceous. (p. 95)

8—*Camerina* sp. cf. *C. parvula* (Cushman). Horizontal section, $\times$21. Upper Eocene. (p. 95)

9—*Lepidorbitoides* (*Lepidorbitoides*) *macgillavryi* Thiadens, n. sp. Horizontal section, $\times$34. Upper Cretaceous. (p. 101)

13—*Dictyoconus fontabellensis* (Vaughan). Outside of the base with apertures, $\times$18. Upper Eocene. (p. 94)



Thiadens, Cretaceous and Tertiary Foraminifera

UNIV. OF MICH.

mm. to 5 mm. (see also text-fig. 2B), average 4.2 mm.; thickness, 0.4 mm. to 0.7 mm., average 0.6 mm.

Remarks.—This species is distinguished from all known species of *Lepidorbitoides* by its flatness and small size in combination with the hexagonal equatorial chambers and the absence of pillars. It is named in honor of Prof. L. M. R. Rutten.

Occurrence.—Upper Cretaceous, Loc. L 128 (map A) type locality, near Abra de Castellon, 13 km. east-southeast of San Fernando, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15779–D15810.

LEPIDORBITOIDES (LEPIDORBITOIDES) RUTTENI var. ARMATA Thiadens, n. var.
Plate 16, figure 6; Text-figures 2A, B; 3G, L

This variety is characterized by a fine to coarse papillate surface, the papillae being the ends of pillars. The papillae are thickest in the center, diminishing in diameter towards the periphery (100–90–80–70–60μ). Lateral chambers are fissiform, arranged in vertical rows, measuring 25$\mu \times 100\mu$.

Occurrence.—Upper Cretaceous, Loc. L 128 (map A), type locality, near Abra de Castellon, 13 km. east-southeast of San Fernando, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15811–D15852.

LEPIDORBITOIDES (LEPIDORBITOIDES) PALMERI Thiadens, n. sp.
Plate 17, figures 2, 9, 10; Text-figures 2A, B

Test of medium size, lenticular, or with a low, broad umbo and narrow margin. Surface smooth, in some cases very finely papillate, with small obscure pillars. Lateral chambers in vertical section rectangular, rather open, measuring 40$\mu \times 90\mu$, arranged in vertical rows. There are about 13 layers. Equatorial chambers hexagonal and spatulate, arranged on concentric circles, measuring 60μ to 110μ (radial) $\times 110\mu$ (tangential). In vertical section the height of the equatorial layer increases from 60μ to 110μ. Embryonal apparatus is typical for the genus, containing a smaller subspherical primary chamber (140μ to 230μ) and the larger reniform second one (210μ to 300μ) The initial chambers are followed by several chambers of diminishing diameter arranged in a spiral. All of these are larger than the other equatorial chambers. Measurements of the test, diameter 3 mm. to 5 mm., thickness, 1 mm. to 2 mm. Embryon, 220$\mu \times$ 300μ to 340μ $\times 370\mu$ (see also text-fig. 2A, B).

Remarks.—This form differs from *L. minor* in the absence of large regularly distributed pillars, and the form of its equatorial chambers; from *L. socialis* in its smaller size and its thickness; from *L. rutteni* and its variety *armata* in its thickness and its larger embryon, and from *L. minima* and *L. nortoni* in the form of the equatorial chambers. This species is named in honor of Mrs. Dorothy K. Palmer.

Occurrence.—Upper Cretaceous, Loc. L 128 (map A), type locality near Abra de Castellon, 13 km. east-southeast of San Fernando, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15867–D15883.

LEPIDORBITOIDES (LEPIDORBITOIDES) MACGILLAVRYI Thiadens, n. sp.
Plate 16, figure 9; Plate 17, figure 7; Plate 19, figure 4; Text-figures 2A, B; 3K

Test small, thickest in the center and thinning quickly towards the periphery, flat conical, symmetrical with respect to the equatorial plane. Surface smooth, reticulate in the very center, in some cases bearing superficial papillae but showing no pillars. Lateral chambers open, thin-walled, rectangular, arranged in vertical rows; 15 lateral layers. Equatorial chambers ogival to diamond-shaped, on intersecting curves, the diagonal measuring about 74μ near the periphery. The equatorial layer increases in height from 25μ to 110μ. Embryonic apparatus of the *Lepidorbitoides*-type. A small subspherical primary chamber and

a larger reniform, slightly embracing, second one. Embryonic apparatus small, measuring 150μ×190μ. The initial chambers are followed by about eight chambers, larger than the other equatorial chambers and arranged in a spiral. Measurements of the test, diameter, 2.4 mm. to 3.7 mm., thickness, 0.8 mm. to 1.1 mm.

Remarks.—This form differs from the above described species and *L. socialis* in having diamond-shaped equatorial chambers. It differs from *L. minor* in the absence of pillars and the smaller embryon; from *L. nortoni* and *L. minima* in its greater thickness and the absence of small pillars. This species is named in honor of Mr. H. J. Mac Gillavry.

Occurrence.—Upper Cretaceous, Loc. L 128 (map A), type locality near Abra de Castellon, 13 km. east-southeast of San Fernando, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15853–D15866.

Genus LEPIDOCYCLINA Gümbel, 1868

This genus has been divided by van de Geyn and van der Vlerk (1935) into the two genera *Lepidocyclina s.s.* and *Orbitoina*. This division is founded on the number of stolons of the equatorial chambers, *Orbitoina* (the genotype of which they did not designate) having four stolons in arcuate, ogival and lozenge-shaped equatorial chambers, and *Lepidocyclina s.s.* having six stolons in mostly hexagonal and spatulate equatorial chambers. It is often difficult to find stolons, and probably because of this fact the authors have not looked over all species of *Lepidocyclina s.l.* in order to determine the number of stolons. Van de Geyn and van der Vlerk have not proved that the presence of arcuate, ogival and lozenge-shaped equatorial chambers always corresponds with the occurrence of four stolons, nor have they shown that hexagonal and spatulate equatorial chambers occur only in forms with six stolons. Tan Sin Hok (1934) described *L. papuliformis* with arcuate equatorial chambers with four stolons in the center of the test and spatuliform equatorial chambers with six stolons toward the periphery. It is difficult to reconcile this with the new classification of van de Geyn and van der Vlerk. The form of the embryonic apparatus and the age of the species cannot support the two proposed new genera, since there are isolepidine forms with arcuate and hexagonal chambers that occur in Eocene as well as Oligocene beds. Since these objections can be made for the present, it seems premature to accept this new classification. Also, van de Geyn and van der Vlerk (1934, 3d chap.) have combined several "species," but "they did not think it necessary to document (their) reasons for eliminating or combining species" (p. 228). In view of this fact I have discussed my specific determinations where it was needed.

EXPLANATION OF PLATE 17

(All specimens from Santa Clara province, Cuba)

FIGS. *1, 3*—*Lepidocyclina* (*Lepidocyclina*) *tschoppi* Thiadens, n.sp. *1*, Horizontal section, ×21. *3*, Vertical section, ×32. Transition beds, upper Eocene-Oligocene. (p. 103)

2, 9, 10—*Lepidorbitoides* (*Lepidorbitoides*) *palmeri* Thiadens, n.sp. *2*, Vertical section, ×17.7 *9*, Horizontal section, ×21. *10*, External view, ×11.6. Upper Cretaceous. (p. 101)

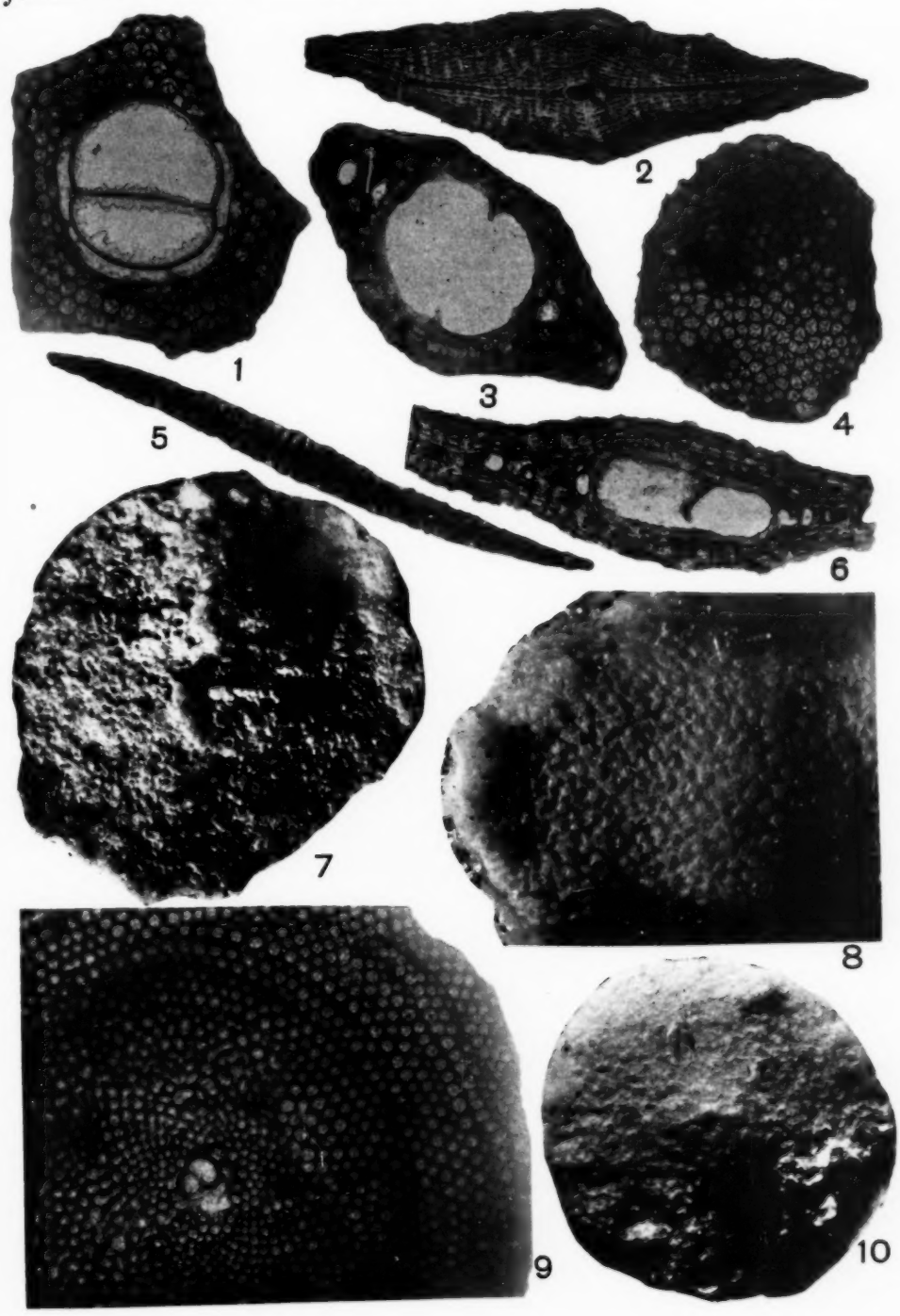
4—*Miogypsina hawkinsi* Hodson. Horizontal section, ×20. Oligocene-Miocene. (p. 107)

5—*Lepidorbitoides* (*Lepidorbitoides*) *rutteni* Thiadens, n.sp. Vertical section, ×20.7. Upper Cretaceous. (p. 100)

6—*Lepidocyclina* (*Neprolepidina*) *fragilis* Cushman var. *cubensis* Thiadens, n. var. Vertical section, ×18.7. Transition beds, upper Eocene-Oligocene. (p. 104)

7—*Lepidorbitoides* (*Lepidorbitoides*) *macgillavryi* Thiadens, n. sp. External view, ×11.7. Upper Cretaceous. (p. 101)

8—*Lepidocyclina* (*Eulepidina*) *undosa* Cushman. External view, ×15. Oligocene. (p. 106)



Thiadens, Cretaceous and Tertiary Foraminifera

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Subgenus LEPIDOCYCLINA Gümbel, 1868

LEPIDOCYCLINA (LEPIDOCYCLINA) MARACAIBENSIS Hodson

Text-figures 2D; 3C

Lepidocyclina maracaibensis HODSON, *1926*, Bull. Am. Paleontology, vol. 12, no. 47, p. 24, pl. 6, figs. 2–4.—RUTTEN and VERMUNT, *1932*, K. Akad. Wetensch. Amsterdam, Proc., vol. 35, no. 2, p. 236, pl. 1, fig. 9; pl. 3, fig. 2.

Test small, thick, umbonate, with a small margin; surface papillate to pustulose; pillars polygonal, measuring in diameter 120μ to 200μ, average 150μ. The equatorial chambers are diamond-shaped or ogival and lie on intersecting curves, measuring 40μ to 60μ (radial) $\times$60μ (tangential). Embryonic apparatus of the isolepidine type, two equal to subequal chambers (diameter, 0.18 mm. $\times$0.27 mm. to 0.37 mm. $\times$0.4 mm.), sometimes followed by two to ten chambers larger than the other equatorial chambers. Measurements of the test: diameter, 1.3 mm. to 1.6 mm. (average 1.85 mm.), thickness, 0.5 mm. to 1.4 mm. (average 1.0 mm.).

Remarks.—There are three specimens with very heavy pillars (diameter 450μ), which I identify as *Lepidocyclina* cf. *maracaibensis*, all the other characteristics being the same as the above mentioned.

Occurrence.—Transitional beds between upper Eocene and Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15528–D15541.

LEPIDOCYCLINA (LEPIDOCYCLINA) MORTONI Cushman

Lepidocyclina mortoni CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 125-D, pp. 70, 71, pl. 27, figs. 1–4; pl. 28, figs. 1, 2.—GRAVELL and HANNA, *1935*, Jour. Paleontology, vol. 9, no. 4, pp. 337–339, pl. 31, figs. 1–11; pl. 32, figs. 1–4. Not *Lepidocyclina mortoni* M. RUTTEN, *1935*, Jour. Paleontology, vol. 9, no. 6, pp. 538, 539.

The Cuban specimens agree well with the extensive description given by Gravell and Hanna. Selliform, with or without umbo. Measurments of the test: diameter up to 10 mm.; thickness up to 2 mm., mostly about 1.2 mm. This form greatly resembles *L. supera* (Conrad, 1865). M. Rutten (1936) found this species in upper Eocene beds. The two species are different in the form of the equatorial chambers, *L. mortoni* having ogival chambers arranged in intersecting curves and *L. supera* spatulate to short-hexagonal chambers arranged in concentric circles. Van de Geyn and van der Vlerk (1934) erroneously combined these two species.

Occurrence.—Upper Eocene and the transitional beds between upper Eocene and Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15551–D15569, D16095–D16098.

LEPIDOCYCLINA (LEPIDOCYCLINA) TSCHOPPI Thiadens, n. sp.

Plate 17, figures 1, 3; Plate 18, figure 6; Plate 19, figure 1; Text-figure 3*H*

Test small, very thick, lenticular and in some cases with an umbo and small margin. Surface papillate, pillars (70μ in diameter) difficult to see. Lateral chambers irregular and thin-walled, on vertical section difficult to distinguish, as the thickness of the lateral layers on either side of the equatorial layer is only 180μ in the center and decreases toward the periphery. There are at least two layers. The equatorial chambers are hexagonal and spatulate [140μ (radial) $\times$110μ (tangential), thickness of the wall 25μ]. Embryonic apparatus very large, of the lepidocycline s.s. type, two equal to subequal chambers with a 25μ thick wall. The ratio of the volume of the very large embryon to the remainder of the test is typical for this species.

Measurements of Lepidocyclina (Lepidocyclina) tschoppi *Thiadens, n. sp.*

Diameter (mm.)....	1.7	1.85	2.0	2.22	2.22	2.22	2.6	2.7
Thickness (mm.)...	0.9	1.4	0.8	1.1	1.2	1.4	1.2	1.1
Embryon (mm.)....	0.6	0.9	0.9	0.96	1.0	0.8	1.1	0.7
	$\times$0.7	$\times$1.0	$\times$0.95	$\times$0.96	$\times$1.1	$\times$0.9	$\times$1.2	$\times$1.1

The embryon is followed by about four large, long, narrow chambers.

Remarks.—This species is different from all known species of the genus, being characterized by its enormous embryon in proportion to the rest of the test. This species is named in honor of Dr. H. J. Tschopp.

Occurrence.—Transitional beds between upper Eocene and Oligocene. Type locality L 588 (map B), 2.5 km. northeast from Jatibonico, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15583–D15590.

LEPIDOCYCLINA (LEPIDOCYCLINA) WEEKSI Hodson

Text-figure 2*D*

Lepidocyclina weeksi HODSON, *1926*, Bull.Am. Paleontology, vol. 12, no. 47, p. 23, pl. 6, figs. 6–8.—RUTTEN and VERMUNT, *1932*, K. Akad. Wetensch Amsterdam, Proc., vol. 35, no. 2, p. 235, pl. 1, fig. 6.

I have two specimens of this species. They have no umbo and are discoidal. Measurements: diameter, 2.0 mm. to 2.1 mm.; thickness, 0.5 mm. to 0.8 mm.; embryon, 0.37 mm. to 0.33 mm. ×0.4 to 0.7 mm.

Papillate, equatorial chambers ogival and diamond-shaped, arranged on intersecting curves.

Remarks.—Van de Geyn and van der Vlerk have combined under the name *L. trinitatis* H. Douvillé the following: *L. trinitatis*, *L. hieronymi* (Rutten and Vermunt), *L. schotborghi* (Rutten and Vermunt), *L. weeksi* Hodson, and others. I have restudied the material of these four species available in Utrecht, and have combined the results in a diagram, in which I also placed *L. maracaibensis* Hodson.

My opinion is that as long as no one has been able to restudy large collections from different localities and work them out statistically, it is not permissible to combine the four above-mentioned species. Therefore, for the present I maintain *L. weeksi*.

Occurrence.—Transitional beds between upper Eocene and Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15953–D15954.

Subgenus NEPHROLEPIDINA H. Douvillé, 1911

LEPIDOCYCLINA (NEPHROLEPIDINA) FRAGILIS Cushman, var. CUBENSIS Thiadens, n. var.

Plate 17, figure 6; Plate 18, figure 7

The difference between the new variety and *L. fragilis* is to be found in the form of the equatorial chambers, *L. fragilis* having rather thick-walled isodiametrical to flat-hexagonal and ogival equatorial chambers, and the new variety having very constantly equatorial chambers of an elongated hexagonal form with a larger radial than tangential diameter, measuring 200μ (radial) ×148μ (tangential) to 150μ ×120μ.

Occurrence.—Transitional beds between upper Eocene and Oligocene, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15955–D15971.

EXPLANATION OF PLATE 18

(All specimens from Santa Clara province, Cuba.)

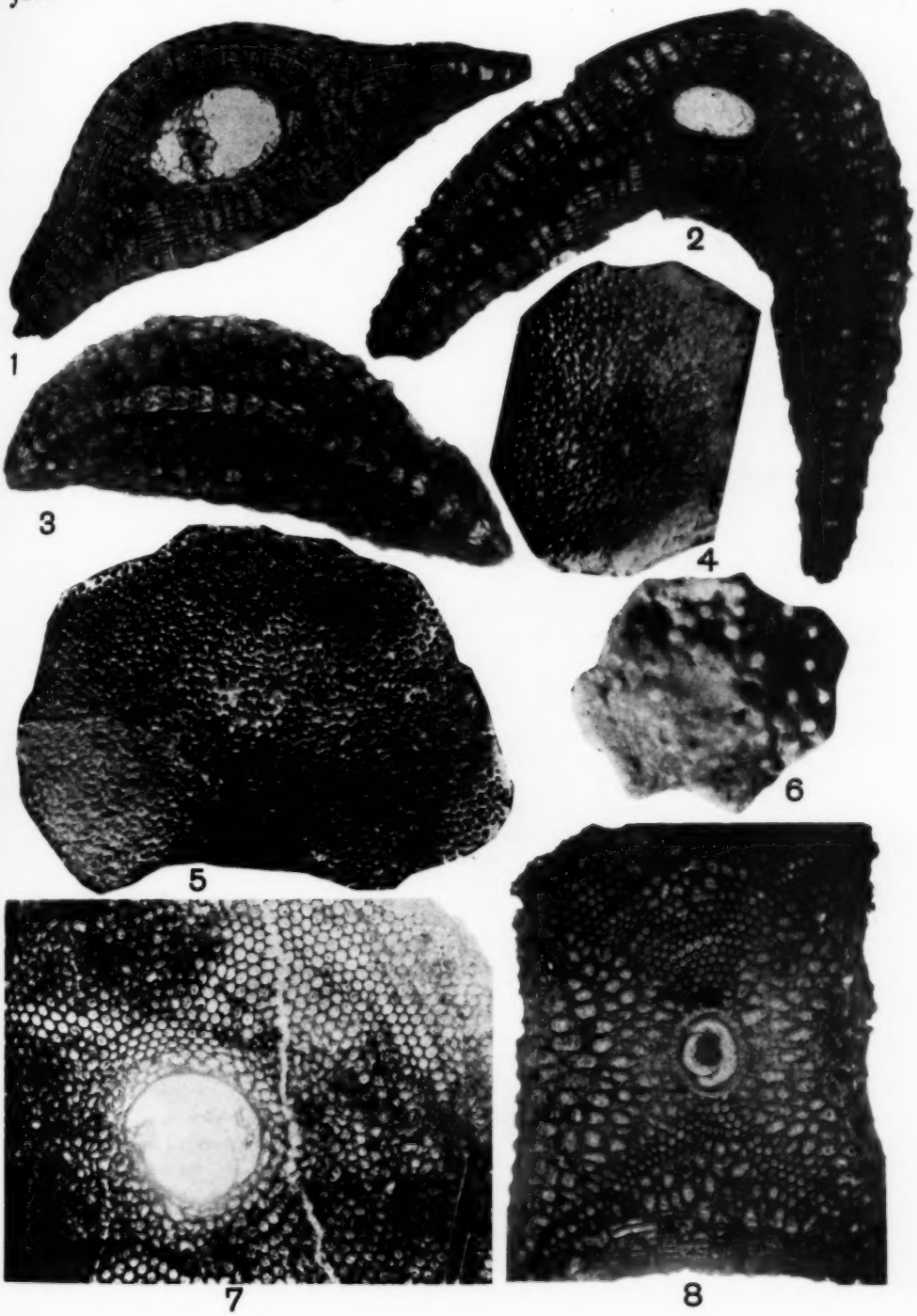
FIGS. *1, 5*—*Lepidocyclina* (*Eulepidina*) *petri* Thiadens, n.sp. *1*, Vertical section, ×23.7. *5*, External view, ×10. Oligocene. (p. 107)

2, 4, 8—*Lepidocyclina* (*Nephrolepidina*) *undosa* Cushman. *2*, Vertical section, ×11. *4*, External view, ×6.3. *8*, Horizontal section, ×11. Oligocene. (p. 106)

3—*Miogypsina hawkinsi* Hodson. Vertical section, ×33. Oligocene-Miocene. (p. 107)

6—*Lepidocyclina* (*Lepidocyclina*) *tschoppi* Thiadens, n.sp. External view, ×10. Transition beds, upper Eocene-Oligocene. (p. 103)

7—*Lepidocyclina* (*Neprolepidina*) *fragilis* Cushman var. *cubensis* Thiadens, n. var. Horizontal section, ×13.8. Transition beds, upper Eocene-Oligocene. (p. 104)



Thiadens, Tertiary Foraminifera

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Subgenus EULEPIDINA

LEPIDOCYCLINA (EULEPIDINA) FORMOSA Schlumberger

Lepidocyclina formosa SCHLUMBERGER, *1902*, Geol. Reichs-Mus. Leiden Samml., ser. 1, Band 6, pp. 251, 252, pl. 7, figs. 1–3.—H. DOUVILLÉ, *1924*, Soc. géol. France, Mém. 2 (n. sér.), p. 49, pl. 6, fig. 4, p. 79, text-figs. 69, 70 *a*, *b* and *c*.

Lepidocyclina favosa CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, p. 66, pl. 3, figs. 1b, 2; pl. 15, fig. 4.—VAUGHAN, *1933*, Smithsonian Misc. Coll., vol. 89, no. 10, pp. 37–41, pl. 17, figs. 1–3; pl. 18, figs. 1–4; pl. 19, figs. 1–4; pl. 20, figs. 1–3; pl. 21, figs. 1, 3; pl. 29, fig. 4.—VAN DE GEYN and VAN DER VLERK, *1935*, Leidsche Geol. Med., Deel 7, afl. 2, pp. 234, 235, 249.

The material from Santa Clara province, Cuba, gives occasion for some remarks. The most striking feature is the coarse reticulate surface of the umbo. There are no pillars. The embryonal apparatus is mostly typical eulepidine; sometimes, however, tending to the nephrolepidine type.

Remarks.—In the original description Schlumberger sketches the test of *Lepidocyclina formosa* as consisting in the middle of a thick cushion with four rays.

On voit au centre une loge initiale sphérique de 0.6 mm. de diamètre complètement enveloppée d'une seconde loge sphérique de 1 mm. de diamètre. Les loges équatoriales qui les entourent ont un contour nettement demicirculaire. . . . Les loges latérales audessus et audessous sont traversées par le très nombreux piliers massifs réciproquement réunis par des nombreuses anastomoses et réservant entre eux des plages occupées par des loges laterales superposées en ligne droite, très surbaissées et séparées par de très minces parois. Les piliers se prolongent jusqu'à la surface extérieure où ils se terminent par des boutons saillants arrondis. . . . Dimensions. L'individu Fig. 2, a 18 mm. environ entre les extrémités des rayons, tandis que le corps central n'a que 6 mm. de côté et une épaisseur au milieu d'environ 2 mm. (Fig. 3).

Douvillé (1905) proved that the test is not stellate but saddle-shaped.

Douvillé (1912 and 1924), L. Rutten (1912 and 1914), and van der Vlerk (1925) proved that the vertical walls of the lateral chambers are very thick and that there are no pillars.

The original description of *L. favosa* Cushman follows:

Test of medium size, compressed, strongly undulate or saddle-shaped, the central portion umbonate, much curved and thick; the remainder of the test thin and flange-like; central umbonate mass with an ornamentation of polygonal areas formed by raised ribs; remainder of the test very smooth but irregularly eroded in most cases. Vertical section with numerous distinct pillars in the umbonate region, broad at the exterior and narrowing to a point near the equatorial chambers, flattened peripheral portion with few indistinct pillars. Diameter 15 to 18 mm. for typical specimens.

Vaughan (1924) says that *L. favosa* is of the eulepidine type, with short spatulate to short hexagonal equatorial chambers, while *L. formosa* should have longer spatulate equatorial chambers. However, van der Vlerk (1925, figs. 27, 28) shows *L. formosa* with short hexagonal and short spatulate equatorial chambers, and in the Cuban specimens of "*L. favosa*" we have in some cases "long" hexagonal chambers. Vaughan (1926) mentions pillars for *L. favosa*. He separates the two species in three features, but these are not valid; for *L. formosa* is selliform and has a margin also (Vide Schlumberger, 1902, figs. 2, 3); the size of *L. favosa* also may be very large and is variable. Vaughan (1933) mentions pillars for *L. favosa*. M. G. Rutten (1935) thinks it probable that *L. favosa* has no pillars since he could find none in his material nor in the figures published by Vaughan. He thinks it probable that pillars are always absent in this species. The same conclusion can be made in connection with my material. The literature on the two discussed species and examples of *L. formosa* from Borneo and "*L. favosa*" from Cuba that are available in Utrecht show that there is not enough difference between the two species to warrant their separation.

Nuttall (1926) says that the specific difference between *L. formosa* and *L. ephippioides* Jones and Chapman (1900) is based on the form of the embryonic apparatus. If it should appear, as Yabe believes (1929), that *L. ephippioides* is also of the eulepidine type, then there is no specific difference between the two last mentioned species and we should be obliged to combine the three species under the name *L. ephippioides*, this being the oldest. Van de Geyn and van der Vlerk (1935) have already combined *L. favosa* and *L. formosa*.

In two places *L. formosa* is associated with *Helicolepidina spiralis* and *L. mortoni*. So we have transitional beds between upper Eocene and Oligocene.

Occurrence.—Transitional beds between upper Eocene and Oligocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15606–D15669, D16102, D16103.

Lepidocyclina (Eulepidina) undosa Cushman

Plate 17, figure 8; Plate 18, figures 2, 4, 8

Lepidocyclina undosa Cushman, *1919*, Carnegie Inst. Washington, Pub. 291, p. 65, pl. 25, fig. 1a.

Lepidocyclina (*Nephrolepidina*) *undosa* Vaughan, *1924*, Geol. Soc. America, Bull., vol. 35, pp. 798, 820, pl. 34, figs. 5–7.

Test of medium to large size, strongly selliform, not umbonate. The whole surface beautifully papillate. The papillae are the ends of pillars which have near the surface a diameter of 90μ at the periphery, and 180μ in the center. Lateral chambers lenticular and rectangular arranged on vertical rows measuring 74μ (vertical) $\times$185μ (horizontal). Pillars between these two rows. There are about 10 layers. Equatorial chambers are hexagonal and spatulate arranged on concentric circles. Equatorial chambers 84μ (radial) $\times$110μ (tangential), 150μ $\times$150μ, 180μ $\times$130μ. Height 220μ – 290μ. Embryonic apparatus is of the eulepidine type, large, thick-walled (thickness, 70μ to 150μ). Measurements: diameter 6 mm. to 10.5 mm., average 9 mm; thickness, 1.48 mm. to 3.6 mm., average 2.2 mm.; embryon 0.92 mm. to 1.85 mm.

Remarks.—We found only eulepidine forms. No trace of transition to the nephrolepidine type has been found. However, as our material was compared with topotypes of the species sent to us by Dr. T. Wayland Vaughan, we are sure of our determination. This form, having pillars, being eulepidine and strongly saddle-shaped, is different from all known Eulepidinas. *L. petri*, n.sp., is not strongly saddle-shaped and does not have a typical eulepidine, large, thick-walled embryon, and is smaller in size.

Occurrence.—Oligocene. Type locality L 229 on the east bank of Ramirez River near its mouth (Cienfuegos Bay), Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15670–D15687.

Explanation of Plate 19

(All specimens from Santa Clara province, Cuba, except fig. 9.)

Figs. *1*—*Lepidocyclina* (*Lepidocyclina*) *tschoppi* Thiadens, n.sp. Vertical section, $\times$22. Transition beds, upper Eocene-Oligocene. (p. 103)

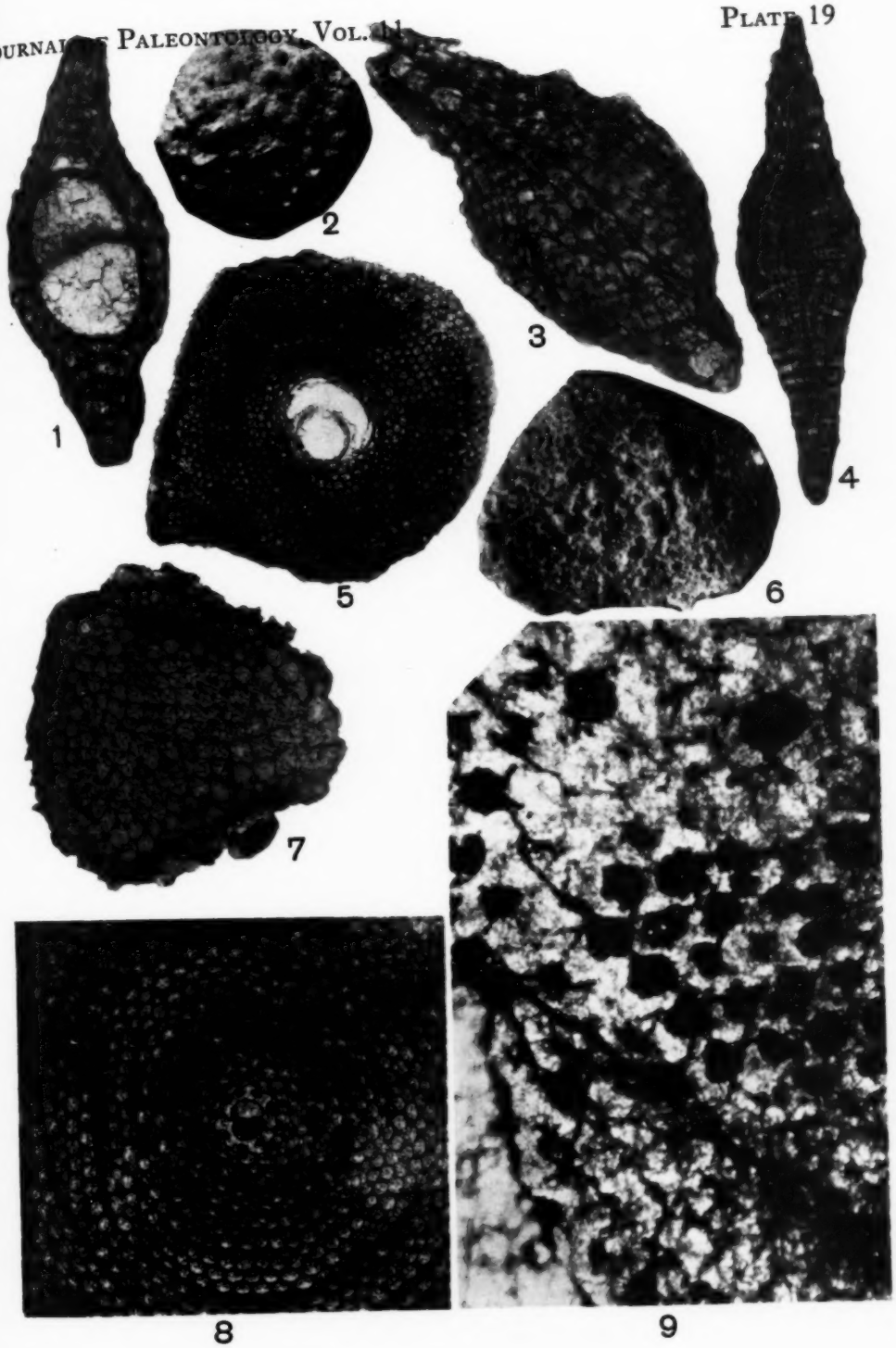
2, 3, 6, 7—*Miogypsina hawkinsi* Hodson. *2*, External view, $\times$20. *3*, Vertical section, $\times$33. *6*, External view, $\times$20. *7*, Horizontal section, $\times$20. Oligocene-Miocene. (p. 107)

4—*Lepidorbitoides* (*Lepidorbitoides*) *macgillavryi* Thiadens, n.sp. Vertical section, $\times$29.5. Upper Cretaceous. (p. 101)

5—*Lepidocyclina* (*Eulepidina*) *petri* Thiadens, n.sp. Horizontal section, $\times$12. Oligocene. (p. 107)

8—*Lepidorbitoides* (*Lepidorbitoides*) *rutteni* Thiadens, n.sp. Horizontal section, $\times$32. Upper Cretaceous. (p. 100)

9—*Lepidorbitoides* (*Lepidorbitides*) *socialis* (Leymerie). Horizontal section showing stolons, $\times$110. Maastrichtian beds near Boussens, France. Photo by M. G. Rutten. (p. 100)



Thiadens, Cretaceous and Tertiary Foraminifera

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LEPIDOCYCLINA (EULEPIDINA) PETRI Thiadens, n. sp.

Plate 18, figures 1, 5; Plate 19, figure 5

Test of medium size, lenticular, in some cases slightly selliform. Surface finely papillate. On tangential section small pillars are visible (diameter 75μ). Lateral chambers low, arranged on vertical rows. There are 10 to 17 layers. Pillars developed from the equatorial layer to the surface or only near the surface. Equatorial chambers hexagonal and spatulate arranged in concentric circles measuring 120μ (radial) ×110μ (tangential) to 180μ ×150μ. Equatorial layer slowly increases in height in the center 90μ to the periphery 220μ. The embryonic apparatus consists of two chambers, the type being a transition from nephrolepidine to eulepidine, mostly nearest the eulepidine type. The embryon is large (diameter, 0.5 mm. ×0.9 mm. to 1.15 mm. ×1.15 mm.), and has a common thick wall, (thickness, 25μ to 37μ). Measurements of the test: diameter 4.2 mm. to 7.5 mm.; thickness, 1 mm. to 2.2 mm.

Remarks.—This species is closely related to *L.* (*Eulepidina*) *formosa*. The pillars, however, are an obviously different feature. For differences with *L.* (*Eulepidina*) *undosa* see the remarks under that species.

Occurrence.—Oligocene, type locality Loc. M 587 (map B), 5.5 km. east of Sancti Spiritus, Santa Clara province, Cuba. Syntypes, Min.-Geol. Inst., Univ. Utrecht, D15688–D15710.

Genus MIOGYPSINA Sacco, 1893

MIOGYPSINA HAWKINSI Hodson

Plate 17, figure 4; Plate 18, figure 3; Plate 19, figures 2, 3, 6, 7

Miogypsina hawkinsi HODSON, *1926*, Bull. Am. Paleontology, vol. 12, no. 47, pp. 28, 29, pl. 7, fig. 9; pl. 8, figs. 1, 2.

Test is rather variable in form, small, flat discoid, lenticular, symmetrical and asymmetrical with regard to the equatorial plane, in some cases saucer-shaped, triangle to fan-shaped. Sometimes there is a curve in the margin opposite the apical side. Surface papillate to coarse papillate, the papillae being the ends of pillars (diameter of the pillar 50μ (on periphery) to 150μ (in center)). The pillars are as far apart from each other as their diameter. Both microspheric and macrospheric specimens are found, the former being larger and flatter. On vertical section the pillars appear to be conical. Lateral chambers are lenticular to rectangular, arranged in vertical rows, alternating with the chambers of the adjacent rows, thick-walled, roofs and floors cribriform. Equatorial chambers diamond-shaped, arranged on intersecting curves, isodiametrical (diameter 125μ). Vertical section shows in the equatorial layer slightly curved horizontal walls (thickness 25μ), and vertical walls convex in the direction opposite to the initial chambers. The equatorial chambers alternate with adjacent lateral chambers. The macrospheric forms have an embryon apparatus consisting of two chambers subequal, apically situated on the periphery. The larger one on the margin of the equatorial layer measures 0.2 mm. ×0.27 mm. to 0.18 mm. ×0.12 mm. in diameter; the smaller first initial chamber, lying inside the larger second one, measures 0.18 mm. ×1.23 mm. to 0.12 mm. ×0.12 mm. The initial chambers are followed by four to six chambers cyclically arranged around the inner side of the embryon. Measurements of the test: diameter, 2.25 mm. ×2.55 mm; thickness, 0.76 mm.

Remarks.—This species is characterized by its dimensions, apically situated embryon with four to six accessory chambers, and rather coarse papillate surface. It closely resembles *M. bracuensis* Vaughan. In looking over the descriptions of *M. bracuensis* and *M. hawkinsi* the only differing feature I could find is the coarseness of the papillae and pillars, the former having minute papillae and the latter having coarse ones.

Occurrence.—Oligocene-Miocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15711–D15731, D16104–D16107.

Genus DISCOCYCLINA Gümbel, 1868

Subgenus DISCOCYCLINA Gümbel, 1868

DISCOCYCLINA (DISCOCYCLINA) BLUMENTHALI Gorter and van der Vlerk

Discocyclina blumenthali GORTER and VAN DER VLERK, *1932*, Leidsche Geol. Med., Deel 4, afl. 2, p. 111, pl. 16, figs. 2–4.

Test lenticular; surface papillate, the papillae measuring 60μ to 100μ, the distance between the pillars two to three times their diameter, very regularly spread over the whole surface. Embryonal apparatus with diameter 325μ to 500μ.

Occurrence.—Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15747–D15762.

Subgenus ASTEROCYCLINA Gümbel, 1868

DISCOCYCLINA (ASTEROCYCLINA) VERMUNTI M. Rutten

Discocyclina (*Asterocyclina*) *vermunti* M. RUTTEN, *1935*, Jour. Paleontology, vol. 9, no. 6, p. 542, pl. 61, figs. 4, 5; pl. 62, fig. 7.

My material agrees with the description given by M. Rutten. There are two to six heavy pillars in the center and smaller ones on the periphery (measuring respectively 260μ and 80μ). Embryonal apparatus consists of two subequal chambers, the larger one almost embracing the smaller one. Embryon measures 210μ $\times$230μ, is surrounded by a ring of square thick-walled chambers (wall 54μ thick) larger than the adjacent equatorial chambers. Measurements of the test: diameter, 2 mm. to 4.5 mm., thickness, 1.2 mm. to 2.0 mm.

Occurrence.—Upper Eocene, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, D15763, D16108–D16110.

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NOTES ON SOME INTERESTING CRETACEOUS AND TERTIARY FORAMINIFERA FROM THE WEST INDIES

SHOSHIRO HANZAWA

ABSTRACT

This paper describes structural features, studied in thin section, of some fossil Foraminifera from Jamaica, Haiti, and Cuba. Two new genera, *Pellatispirella* and *Paraspiroclypeus*, are described, and the new family, Pellatispiridae, is proposed. A new species is *Pellatispirella antillea*.

During a stay from May 10 to August 20, 1936, at the Scripps Institution of Oceanography, La Jolla, Cal., I had, through the kindness of Dr. T. W. Vaughan, the Director of the Institution, an opportunity to study type specimens of most of the species of orbitoids and other larger Foraminifera described from the Cretaceous and Tertiary formations of America, besides specimens representing many species from Pacific Islands, including undescribed material from these regions. A large part of the collections belongs to the U. S. National Museum in Washington, D. C.; another part is being transferred to the Museum of Paleontology of the University of California in Berkeley. Dr. Vaughan also kindly showed me his collection of topotypes of orbitoids and other higher Foraminifera from Europe, India, and the East Indies, and manuscripts of his works on American Tertiary larger Foraminifera which have not yet been published.

The purpose of the present notes is to describe new forms of Foraminifera and to present interpretations of previously described forms as a result of the study of the abovementioned material. In the preparation of the present paper, I am much obliged to Doctor Vaughan for his continued encouragement, suggestions, criticism, and the free use of his library. Besides, he kindly supplied geological information on the Foraminifera described below, and finally read my manuscript. I express my hearty thanks to him. It is also a pleasure to express my appreciation to Mr. U. S. Armstrong at the Scripps Institution for making some thin sections of *Pellatispirella matleyi* (Vaughan) and to Dr. E. M. Thorp of Baylor University, Waco, Texas, who took time during his stay at the Institution to make most of the photomicrographs for the accompanying plates.

SYSTEMATIC DESCRIPTIONS

Family MILIOLIDAE d'Orbigny, 1839

Genus FABULARIA Defrance, 1820

FABULARIA VAUGHANI Cole and Ponton

Plate 20, figures 1–4

Fabularia vaughani COLE and PONTON, *1934*, Am. Midland Naturalist, vol. 15, no. 2, pp. 138–141, pl. 1, figs. 1–9.

In a single thin section of a limestone which was collected by Dr. C. A. Matley at a place, J 10 M, east of Stony Hill, St. Andrew, Jamaica, I have found two sets of foraminiferal sections, one of which is globular, and the other oval or thick fusiform, each displaying a biloculine plan of growth. The sections with globular outlines strongly resemble an axial section of *Borelis*. Since, however, we do not find sections corresponding to sagittal sections of *Borelis*, which has a coiled plan of growth, it is safe to consider the two sets of sections as transverse and longitudinal sections of one and the same species. Comparison of this species with previously described forms indicates that it is probably identifiable with *Fabularia vaughani* Cole and Ponton, from the Florida Eocene.

The form from Jamaica, study of which was carried out only on microscopical sections, is oval or thick spindle-shaped in longitudinal section, and globular (somewhat compressed) in transverse section. It is 2.25 mm. long, 1.56 mm. high, and 1.14 mm. wide, and consists of eight to ten biloculine-disposed chambers, that is, all the chambers following the proloculum are arranged alternately on each side of a plane through the center of the test; the proloculum is spherical, 170–190μ in diameter; all the chambers of biloculine plan of growth, except the last-formed two or four, are divided into longitudinal channel-like chamberlets, which are round to subtriangular in cross-section and are formed by thin, compact septa running meridionally. The chamber walls are compact, thin, and have almost uniform thickness (15μ) in every chamber. They appear as yellow translucent layers in thin sections under the microscope. The chamber walls are coated with compact dark shell substance (secondary deposit) in variable thickness under the chamberlets. Although the secondary deposits become so great as to fill up the entire open space of the last-formed two or four chambers, within the dark field of the secondary deposits under the microscope there can be seen here and there tiny white spots (15μ in diameter) which are supposed to be irregularly scattered channelled canals; cribriform apertures, each of which has an inwardly directed tube-like lip, are found in an extremity of every chamber. They are seen on the right end of the fourth chamber on Plate 20, figure 4, and also on the right end of the fifth chambers counted from the last one.

Round colorless spots appear in some of the uppermost points of the septa where these connect with the shell walls (pl. 20, figs. 2, 3), the same features being discernible in Plate 1, figure 9, of Cole

Measurements of Fabularia vaughani

Height of chambers (from top of each chamber to top of succeeding chamber)	Length of chambers	Width of chambers	Number of chamberlets	Diameter of chamberlets
1st chamber 67μ	475μ– 470μ	300μ	3?	
2d 75μ	450μ– 760μ	306μ	6	38μ
3d 75μ	620μ–1110μ	371μ	8?	38μ
4th 75μ	750μ–1520μ	450μ	10	
5th 112μ	900μ–2280μ	560μ	10	
6th 110μ	1120μ–2280μ	660μ	12	
7th 180μ	1200μ	750μ	12	
8th 225μ	1350μ	915μ	12–16	100μ×90μ
9th 187μ		1200μ		
10th 150μ				

and Ponton's paper (1934). Although these spots strongly suggest "*pores intercalaires*" in *Rasciolites*, detected by Reichel (1931, p. 293, fig. 1), they may be considered as representing a canal system running along the uppermost part of the septa. Measurements of the specimens are given on page 111.

Remarks.—The present form is indistinguishable from *Fabularia vaughani*. Although the secondary deposit of shell substance may appear to be heavier in the Jamaica specimens than in *F. vaughani* from Florida, the amount of such a deposit is not supposed to be very important in taxonomy.

As stated by Cole and Ponton, *F. vaughani* stands close to *F. zitteri* Schwager (1883, pl. 24, figs. *c–e*, *h*), but the latter has few chambers, is much more compressed, and its septa in some cases are bifurcated. Schwager's specimens, obtained from the Lybian desert (1883), consisted of two different types, one of which, treated by him as a young form, showed a biloculine plan of growth, and the other, treated as an adult form, has a hauerine plan of growth. Schwager (1883, p. 90) states:

> . . . Ich fand z. B. im Kalke von Minieh, wo diese Art [*Fabularia zitteri*] gar nicht selten, ja geradezu charakteristisch ist, nur Jugendzustände.

According to present knowledge, this opinion would not now be held, for the reproductive activities of a foraminifer (Dr. E. H. Myers, 1935, and oral information to me) do not exceed a period of three days, though the life span of an individual varies from a few days in smaller species to perhaps many months in larger species. Therefore, in any geological formation, it is improbable that a limestone is entirely composed of young individuals of Foraminifera, unless there has been most exceptional sorting action. Although Schwager did not give any indication of the internal structure of his so-called adult specimens—and now we cannot know its young stage of growth—I am convinced that his *Fabularia zitteri* should be divided not only into two different species, but into two different genera. Probably a new generic name should be proposed for his so-called adult form of *F. zitteri*, but I do not like to do this in the case of an inadequately described form without examination of the original specimens. I restrict the name *F. zitteri*, however, to Schwager's so-called young forms, shown in his figures *c*, *d*, *e*, and *h* (1883).

Fabularia howchini Schlumberger (1891) described from the Victoria Miocene of Australia, also slightly resembles the present form. This species is known in its microspheric forms alone. Its length is 2.7 mm., width, 2.8 mm., and thickness, 1.2 mm. It is a depressed type.

Occurrence.—J 10 M, 50 yds. east of Stony Hill, St. Andrew, Jamaica, C. A. Matley, collector. Eocene, "white limestone." This species is associated with *Orbitolites*(?) sp. indet. The horizon is

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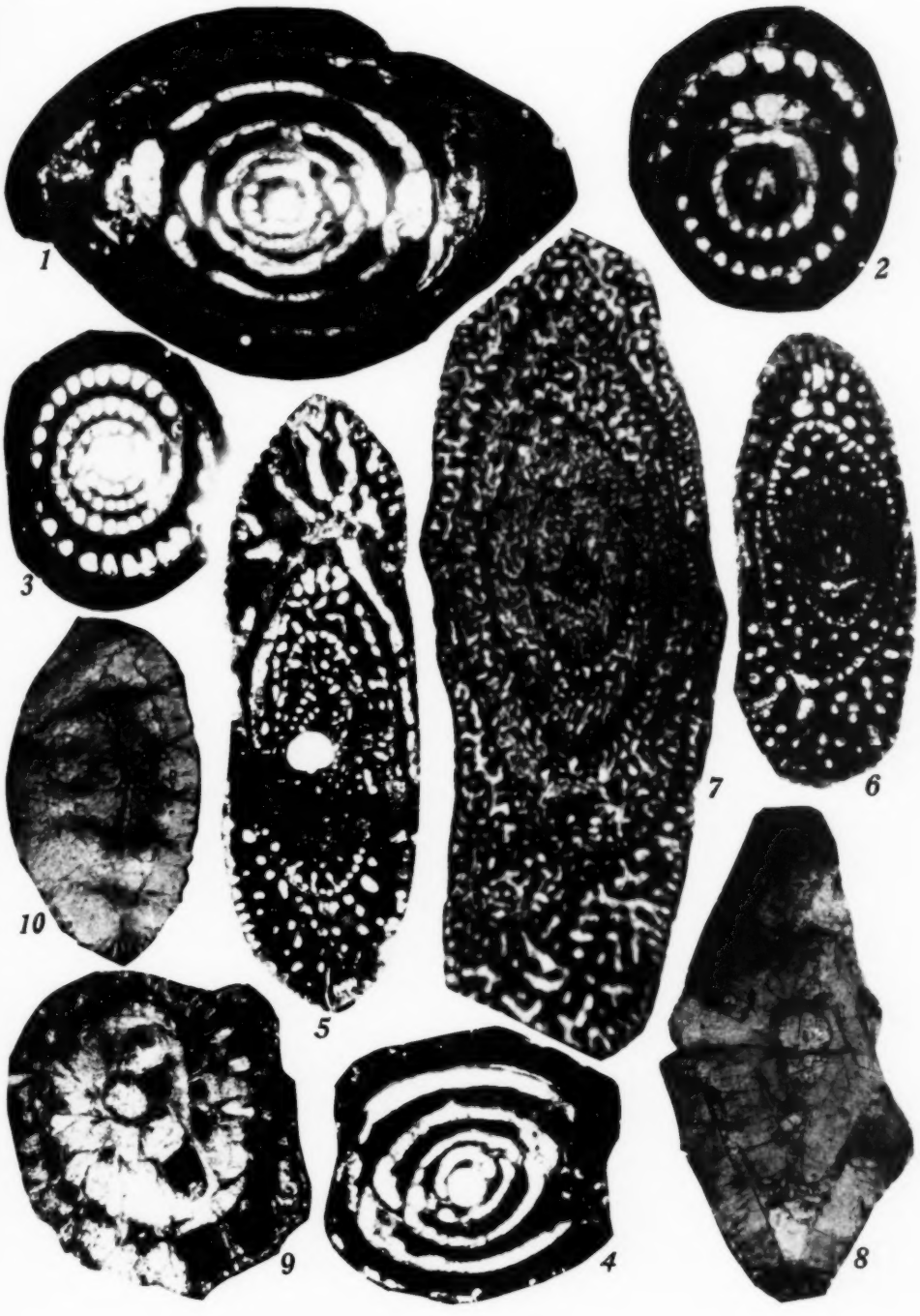
EXPLANATION OF PLATE 20

FIGS. *1–4*—*Fabularia vaughani* Cole and Ponton, ×28.2. Eocene white limestone, J. 10 M, 50 yds. east of Stony Hill, St. Andrews, Jamaica. C. A. Matley, collector. *1*, Longitudinal section near the proloculum. *2*, *3* Transverse sections through the proloculum. *4*, Longitudinal section through the proloculum. (p. 111)

5, *6*—*Fabularia*(?) sp. *A*, ×28.2. Eocene, J 260 b M, Bog Walk Canyon, Jamaica. C. A. Matley, collector. *5*, Transverse section through the proloculum. *6*, Excentric transverse section. (p. 113)

7—*Fabularia*(?) sp. *B*, ×28.2. Eocene J 64 M, Duan Vale borehole (first borehole, abandoned). C. A. Matley, collector. Moneague. (p. 113)

8–10—*Pellatispirella antillea* Hanzawa, n. gen., n.sp., ×28.2. Eocene, H 2 V, Cap Haitien, Haiti. T. W. Vaughan, collector. *8*, Transverse section through the proloculum. *9*, Section slightly oblique to the sagittal plane passing through the proloculum. *10*, Oblique section tangential to the marginal cord of the penultimate whorl. (p. 116)



Hanzawa, Cretaceous and Tertiary Foraminifera

UNIV. OF MICH.

thought to be about the same as that of the Florida Eocene from which Cole and Ponton described *Fabularia vaughani*.

The specimens above described are in the paleontological collections of the University of California at Berkeley; other specimens are in the U. S. Nat. Mus., Washington, D. C.

FABULARIA(?) sp. A
Plate 20, figures 5, 6

Another species of *Fabularia*-like Foraminifera appears in the Jamaica material. It suggests a form illustrated by Carpenter (1862, pl. 6, fig. 38) in which the test appears so much compressed as to be subcylindrical or fusiform in transverse section. The form from Jamaica is 3 mm. in height, 1 mm. in width, and is composed of a spherical proloculum 17 to 22μ wide followed by ten alternately disposed chambers on each side of a plane passing through the center of the test. Regularly disposed chamberlets are seen along the marginal part of the chambers as in *Fabularia vaughani* Cole and Ponton, but their diameters are rather smaller than those of *F. vaughani*, being 15 to 23μ wide; the secondary deposits, lying underneath the marginal chamberlets, are also penetrated by numerous longitudinal canals with about the same diameter as that of the marginal chamberlets.

The *Fabularia* described by W. B. Carpenter (1862) resembles slightly the present form in configuration, but differs in its enormous size (6.25 mm. in length and 4.6 mm. in width).

The present specimens are represented by transverse sections alone, and I cannot be sure, therefore, whether it shows the biloculine or hauerine plan of growth. Moreover, the disposition of canals in the secondary deposit in the last-formed chamber (pl. 20, fig. 5) differs from that of the other chambers. This fact leads us to doubt whether it belongs to the same genus as the so-called adult form of *F. zitteri* Schwager.

A foraminiferal section (pl. 21, fig. 3) which is found in the same section as the above-mentioned form, may be regarded as an oblique section of *Fabularia*, because it has marginal chamberlets and inosculating channelled canals in compact shell substance inside them. It is larger than the *Fabularia*(?) sp. *A*., however, and it is coarser in structure. It is supposed to be a microspheric specimen of *Fabularia*(?) sp. *A*. or a different species.

Occurrence.—Eocene, J 260 b M, Bog Walk Canyon, Jamaica. C. A. Matley, collector. This form is accompanied by *Orbitolites*(?) sp., *Coskinolina* sp., *Lituonella* sp., *Peneroplis*(?) sp., and Miliolidae which probably belong to new genera with *Trillina*-like shell walls. The described specimens are in the U. S. Nat. Mus., Washington D. C., and other specimens are in the paleontological collections of the University of California at Berkeley.

FABULARIA(?) sp. B
Plate 20, figure 7

Another *Fabularia*-like species is represented by only one transverse section. It can be recognized in the illustration that its secondary deposit is penetrated by labyrinthine cavities which in some places have a criss-cross arrangement, as is seen in *Yaberinella* (see Vaughan, 1928, p. 9), and these cavities communicate with marginal chamberlets. Although this form is not identifiable with any previously recorded *Fabularia*, the available material is inadequate to establish a new species.

Occurrence.—Eocene, J 64 M, Duan Vale borehole (first borehole, abandoned), Jamaica. Specimen in the U. S. Nat. Mus., Washington, D. C.

Family PELLATISPIRIDAE Hanzawa, n. fam.

Genus PELLATISPIRA Boussac, 1903

The systematic position of *Pellatispira* Boussac has been a subject of controversy for a long time. Since a history of the study of this genus has been given by Yabe (1921) and Umbgrove (1928), dis-

cussion given by these authors need not be repeated here. Yabe thought that *Pellatispira*, because of its characteristic shell walls, must belong to the Rotaliidae and stand closer to *Calcarina* than to *Assilina*. Umbgrove, on the contrary, assigned it again to the Camerinidae after he detected by Canada-balsam preparations the presence of a marginal plexus in the genus. Galloway (1933, p. 417) followed Umbgrove's opinion, while Cushman (1933, p. 248) placed it in the Calcarinidae.

Although Boussac (1903, p. 91) did not mention the marginal plexus (*"le canal spiral,"* chamber-cavity), a rather thick dark line in the chamber walls that is discernible to the left-hand side of his illustration (fig. 11) seems as if it may be a marginal canal. I am not quite sure on this matter because it is dangerous to judge such delicate microscopical structure by photomicrographs alone. Anyway, the presence of a marginal plexus in *Pellatispira* is indisputable, as shown by Umbgrove's study. If *Pellatispira* has a marginal plexus, it must not be placed in the Calcarinidae. Furthermore, it has not only a double-layered marginal cord, as mentioned below, but also thick straight vertical canals in the shell walls and in the umbonal regions. Vertical canals are always found in the genera *Calcarina*, *Rotalia*, and *Elphidium*, especially in their umbonal regions, but never in *Camerina*, *Assilina*, *Operculina*, *Heterostegina*, and *Spiroclypeus*.

While the marginal cord in *Operculina* and *Camerina* is made up of a single layer traversed by regularly or irregularly ramifying canals (Carpenter, 1862, pl. 18, figs. 3, 6, 9; Hofker, 1927, pl. 33, fig. 1) that of *Pellatispira* consists of double layers—a thin, inner, finely perforated layer, and a thick, outer, coarsely perforated layer. The outer layer differs from the marginal cord of *Operculina* and *Camerina* in that it is pierced by numerous thick vertical canals. Tangential canals, such as are seen in the marginal cord of *Operculina* and *Camerina*, are not found in it except that some branches of canals from the main canals lie between the inner and outer layers (Umbgrove, 1928, figs. 11–15, 20–23, etc.).

We must separate *Pellatispira* from the Camerinidae because of its characteristic marginal cord and its vertical canal system, and it must be discriminated from the Calcarinidae, Rotaliidae, and Nonionidae because it has a marginal cord and has no spiral canal system such as is characteristic of the latter. *Pellatispira* should be considered as occupying an intermediate position between the Camerinidae and Calcarinidae. For genera that occupy this intermediate position, I propose the new family name, Pellatispiridae.

Genus PELLATISPIRELLA Hanzawa, n. gen.

Genotype *Camerina matleyi* VAUGHAN, *1929*, Jour. Paleontology, vol. 3, no. 4, pp. 376, 377, pl. 39, figs. 2–7.

Pellatispirella, here proposed as a new genus, belongs in the Pellatispiridae. It is distinguished from *Pellatispira* in being involute through life. The alar prolongation of chambers in *Pellatispirella* overlaps toward the center of the test, whereas the chamber in *Pellatispira* are restricted to the equatorial part of the test. The apertural features of *Pellatispirella*, as mentioned below, are peculiar.

In *Pellatispirella matleyi* (Vaughan), the shell walls are as distinctly differentiated into double layers as in *Calcarina*, and they obscure the boundary between the shell walls (spiral laminae) and the marginal cord. In *Pellatispirella antillea*, n. sp., such a differentiation of shell walls into double layers, as stated below, is almost confined to its marginal cord, but the vertical canal system is well developed in the spiral laminae, umbonal region, and in the marginal cord.

The other characteristics of *Pellatispirella* are its apertural features. While *Camerina* and *Operculina* usually have a single slit-like aperture at the median part of the base of the septa, *Pellati-*

spirella has small multiple apertures along the base of the septa.

From an examination of the original material of *Operculina bermudezi* Palmer (1934, pp. 238–240, pl. 12, figs. 3, 6–9, text-fig. 1) from the Upper Cretaceous of Cuba, it is obvious that this form belongs to *Pellatispirella*. Its chambers are equitant, its spiral laminae are in places coarsely perforated by vertical canals, and its marginal cord has the characteristic structure of the Pellatispiridae.

As to *Camerina dickersoni* Palmer and (?)*Camerina cubensis* Palmer (1934, pp. 243–246), available material is inadequate to scrutinize the internal structure of the species, but the delicate pectination perceptible along the margin of the test leads us to wonder if they may not be small species of *Pellatispirella*.

Geological age.—Upper Cretaceous to Eocene.

PELLATISPIRELLA MATLEYI (Vaughan)
Plate 21, figures 4–7

Camerina matleyi VAUGHAN, *1929*, Jour. Paleontology, vol. 3, no. 4, pp. 376, 377, pl. 39, figs. 2–7.

T. W. Vaughan's description of this species is as follows:

Test small, lenticular, outer surface without ornamentation except the trace of flexuous septal markings. Diameter from 1.6 to 2.4 mm., thickness from about 0.75 to 1.25 mm. Although the thickness varies, it is approximately one-half of the diameter.

The number of coils in a specimen 1.75 mm. in diameter is about four and the number of chambers in the last coil is about 33. The chamber wall gently curved.

The specimens examined are all megalospheric.

Geological horizon and locality.—Middle Eocene, "Yellow limestone," at J 505 M, Phantilland parochial road 1.8 miles from the main road, on the boundary of St. Elizabeth and Manchester Parishes; J 605 M, Davyton road at 4⅞ miles Peace River District, Clarendon Parish.

After I reexamined topotypes of this species, I noticed that it should be generically distinguished from *Camerina*, because its spiral laminae are composed of double layers, as seen in *Calcarina*, and it is provided with thick straight vertical canals in the umbonal regions (the coarse perforation of the spiral laminae should also be interpreted as a vertical canal system). Moreover, its multiple apertures, of which the median one is the largest (37μ × 18μ in diameter), and the other, small (10μ in diameter) ones, are disposed at the base of the septa and are separated from each other by intervals nearly equal to the diameter of each aperture.

Occurrence.—Eocene. The specimens illustrated on plate 21, figures 5–7, were found in a limestone by C. A. Matley from locality J 506 M, east of George's Valley, St. Elizabeth, middle slope, Jamaica. Although they cannot be freed from the matrix, their cavities and hollows are impregnated by iron oxide so that their delicate internal structure is clearly recognizable. They are safely identified with *Pellatispirella matleyi* (Vaughan). Other material (pl. 21, fig. 4) comes from a "yellow limestone marl" at J 605 M, on Davyton road.

Dimensions of Pellatispirella matleyi (*Vaughan*)

	J 605 M	J 506 M
Diameter of test	1.6 –2.4 mm.	1.7 mm.
Thickness of test	0.75–1.25 mm.	0.7 mm.
Diameter of proloculum	135μ	165–187μ
Thickness of proloculum wall	15μ	15μ
Thickness of septa in the last whorl	22μ	22μ
Diameter of interseptal canals	7μ	7μ
Thickness of spiral laminae (penultimate whorl)	±68μ	±60μ
Thickness of the outer layer of spiral laminae	±57μ	±43μ
Thickness of the inner layer of spiral laminae	±11μ	±17μ
Diameter of pore-canals in the outer layer (pore-canals widen toward the bottom)		17–7μ
Diameter of pore-canals in the inner layer		6μ

PELLATISPIRELLA ANTILLEA Hanzawa, n. sp.
Plate 20, figures 8–10; Plate 21, figure 1

This new species is established from study of thin sections of a limestone collected by Doctor Vaughan from Cap Haitien, Haiti, H 2 V; no free specimens are at my disposal.

Test thick, lenticular, attaining 2.5 mm. in diameter and 1.2 mm. in thickness, but usually 2 mm. in diameter and 1.2 mm. in thickness; involute, consists of two and a half or sometimes three whorls; several conical plugs developed on both sides of the umbilical regions; proloculum spherical or ellipsoidal, 230 to 290μ or 230$\times$320μ in diameter, surrounded by a thick wall 15 to 30μ thick; spiral laminae of the first and second whorls thick, attaining 228μ in thickness, that of the last whorl thinner, 75μ thick; whorls divided into chambers by radial, straight double septa; number of chambers 7 to 8 in the first whorl, 14 to 15 in the second whorl, and 7 to 20 in the last whorl; spiral laminae in general finely perforated, penetrated in places by thick vertical pores (7μ in diameter), which usually open on both the upper and lower surface of the spiral laminae, but sometimes closed near the bottom by the ordinary finely perforated walls so as to make a double-layered lamina, as in *P. matleyi* (Vaughan); straight vertical canals well developed in umbonal region around compact conical plugs; marginal cord showing characteristic features as already mentioned; apertures multiple along the base of the septa.

The specimens examined are all megalospheric.

Occurrence.—Eocene. H 2 V, Cap Haitien, Haiti. T. W. Vaughan, collector, 1919. This species is accompanied by a small species of *Discocyclina*. Syntypes, U. S. Nat. Mus., Washington, D. C.

PELLATISPIRELLA sp.
Plate 21, figure 2

The form here illustrated may indisputably be assigned to *Pellatispirella*. The figure shows a transverse section of the marginal part of a specimen. It is a large, flat, discoidal form with a conspicuously developed marginal cord and spiral laminae which in places are differentiated into double layers by evenly distributed thick vertical canals. Although the figure suggests that it is an evolute type of growth, such as that of *Pellatispira*, it has been crushed in fossilization and does not show the original state of the specimen. We can see equitant chambers in the other part of the same specimen.

Occurrence.—Eocene. H 2 V, Cap Haitien, Haiti. T. W. Vaughan, collector, 1919. The specimen here described is in the U. S. Nat. Mus., Washington, D. C.

Family CAMERINIDAE Meek and Hayden, 1865

Genus PARASPIROCLYPEUS Hanzawa, n. gen.

Genotype, *Camerina chawneri* PALMER, *1934*, Soc. cubana hist. nat., Mem., vol. 8, pp. 261, 262, pl. 16, figs. 3, 6, 7. Upper Oligocene, Cuba.

The most characteristic features of *Camerina chawneri* Palmer are the spiral laminae which are subdivided into several layers so as to leave some empty spaces between them, the interspaces

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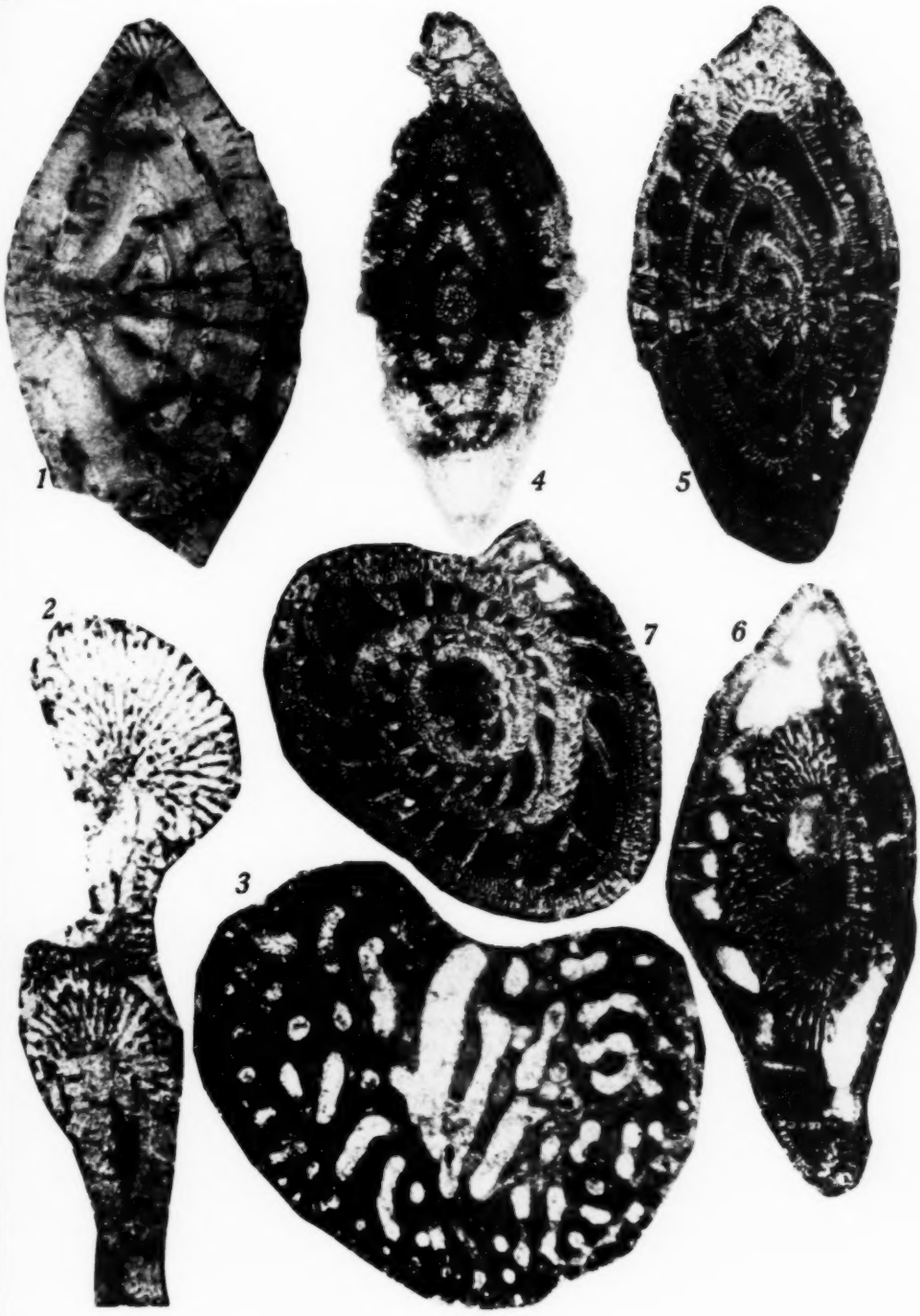
EXPLANATION OF PLATE 21

FIGS. *1*—*Pellatispirella antillea* Hanzawa, n. gen., n. sp., $\times$28.2. Eocene, H 2 V, Cap Haitien, Haiti. T. W. Vaughan, collector. Oblique section near the center of the test. (p. 116)

2—*Pellatispirella* sp., $\times$28.2. Eocene, H 2 V, Cap Haitien, Haiti. T. W. Vaughan, collector. Transverse section. (p. 116)

3—*Fabularia*(?) sp., $\times$28.2. Eocene, J 260 b M, Bog Walk Canyon, Jamaica. C. A. Matley, collector. Oblique section. (p. 113)

4–7—*Pellatispirella matleyi* (Vaughan), $\times$52.5. *4*, Eocene. "Yellow limestone," J 605 M, Davyton Road at 4 7/8 miles, Jamaica; C. A. Matley, collector; transverse section cut through the proloculum and septa. *5–7*, Eocene, J 506 M, east of George's Valley, St. Elizabeth, Jamaica, middle slope; C. A. Matley, collector. *5*, Transverse section through the proloculum. *6*, Transverse section cut apart from the proloculum. *7*, Section slightly oblique to the sagittal plane passing through the proloculum. (p. 115)



Hanzawa, Cretaceous and Tertiary Foraminifera

UNIV. OF MICH.

being subdivided into chambers by anastomosing vertical partitions. The subdivision of the interspaces between layers of spiral laminae into chamberlets remind us of those of the genus *Spiroclypeus*. The equatorial layer has the same features as in *Operculina*. This form of Foraminifera is interpreted as an advanced type of Operculinoides. For this I propose a new generic name, *Paraspiroclypeus*, with *Paraspiroclypeus chawneri* (Palmer) as genotype.

The holotype and paratypes are in the U. S. Nat. Mus., Washington, D. C.

ADDENDUM

After the manuscript of this paper had been sent to press, through the courtesy of T. W. Vaughan and L. G. Henbest, I had the privilege in January, 1937, of examining thin sections in the U. S. National Museum, Washington, D. C., that contain the original specimens of *Fabularia*(?) sp. *B*, described above. In these sections, I found, besides the specimen illustrated in the present note, several other specimens assignable to the same species. Although the available material is inadequate for a precise study of its structure, the species is more likely referable to the genus *Yaberinella* than to *Fabularia;* it shows the criss-cross labyrinthic structure characteristic of *Yaberinella* in its horizontal as well as its vertical section. Since the present form slightly exceeds 4.4 mm. in diameter and 1.5 mm. in thickness (a megalospheric specimen has a proloculum 200μ in diameter), it is near *Yaberinella trelawniensis* Vaughan (1929) but appears to be somewhat thicker. It is accompanied by other species of Foraminifera assignable to *Lepidocyclina* (*Polylepidina*) *chiapasensis* Vaughan (1924), *Dictyoconus americanus* (Cushman) (1919; Vaughan, 1932), and *Amphistegina lopeztrigoi* Palmer (1934 p. 255, pl. 15, figs. 6, 8; Barker and Grimsdale, 1936, p. 223, pl. 30, figs. 1, 2; pl. 32, figs. 1–3; pl. 34, figs. 1, 3.).

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SHOSHIRO HANZAWA, TOHOKU IMPERIAL UNIVERSITY, SENDAI, JAPAN. MANUSCRIPT RECEIVED BY THE EDITOR, AUGUST 20, 1936.

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FUSULINIDS OF THE SUBFAMILY SCHUBERTELLINAE

M. L. THOMPSON

ABSTRACT

A restudy of the genotype of *Schubertella* Staff and Wedekind and associated fusulinids indicates that this form is Permian in age, and that several of its internal structures were neither correctly described nor illustrated by Staff and Wedekind. In this paper *Schubertella* is discussed at some length, topotypes of its genotype are described and illustrated, its distribution is summarized, and its relationship to closely similar forms is discussed. The new subgenus *Eoschubertella* is established for Lower Pennsylvanian forms which are considered ancestral to *Schubertella s.s.*, and the genus *Depratella* Ozawa is placed in synonymy with *Schubertella*.

Staff and Wedekind (1910) established *Schubertella* with *S. transitoria* Staff and Wedekind as genotype. The syntypes of the genotype have apparently been lost and widely differing opinions as to their true nature have been expressed. *Schubertella* has been placed in synonymy with several other genera, and its genotype has been considered Lower Pennsylvanian in age by some, and Permian in age by others.

Dr. Hubert G. Schenck recently sent me several samples of fusulinid-bearing limestone from different parts of Spitzbergen that were given to him in Europe by Professor Erik Stensiö, of the Riksmuseum in Stockholm. These collections were obtained by A. G. Nathorst in 1882, and the localities from which they were made were described by him (1910) in his discussion of the geology of Spitzbergen. One of these collections came from Tempel Bay and it contains numerous representatives of a very small fusulinid which, so far as can be determined from Staff and Wedekind's description and illustrations (drawings), are conspecific with at least part of the syntypes of *Schubertella transitoria* Staff and Wedekind. Also, conspecific specimens are present in a hand specimen of the collections I am studying labeled as coming from Isfjord. Staff and Wedekind's Spitzbergen collections consisted of individual hand specimens of limestone from Tempel Bay and Klas Billen Bay (Mimersbukt) and, although they did not state from which of these localities their syntypes of *S. transitoria* were obtained, it is probable that the specimens I am studying came from the same horizon and locality as at least part of the syntypes of that species. It is entirely possible that these syntypes came from both Tempel Bay and Klas Billen Bay, for the associated fusulinids show that their samples from the two localities are of essentially the same age.

A detailed study of this well-preserved material, which I am regarding as topotype material of *S. transitoria*, shows that the species possesses a spirotheca composed of a tectum and a rather thick inner layer of light material. Its juvenarium has a

large form ratio and its axis of coiling is at a large angle to the axis of coiling of the outer fusiform volutions. A study of the associated fusulinids of this form indicates clearly that it is Permian in age.

Determination of the true nature of the type of *Schubertella* necessitates a slight revision of the nomenclature of the minute fusulinids of the Pennsylvanian and Permian. The subfamily Schubertellinae Skinner must be emended so as to include the minute fusulinids of the Permian of which *Schubertella* is a member. Also, the new subgenus *Eoschubertella* is established below for the minute primitive Lower Pennsylvanian fusulinids formerly referred to *Fusulinella* and *Schubertella*.

Studies made since Staff and Wedekind's report indicate that a very large and varied fauna of minute fusulinids occurs in the Permian of many regions. Deprat (1913) has described and illustrated a form from the Permian of French Indo-China as *Neofusulinella lantenoisi*. This species, which is the type of *Neofusulinella* Deprat, is apparently closely related to the genotype of *Schubertella*. Later Deprat (1915) described three very minute fusulinids which represent *Schubertella* from the Permian of French Indo-China as *Neofusulinella elongata*, *N. giraudi*, and *N. minima*. Still later Ozawa (1928) made *N. giraudi* the type of *Depratella* Ozawa. Hence, *Depratella* must be regarded as a synonym of *Schubertella*, which has priority.

Colani (1924) described and illustrated a species of *Schubertella* from the Uralian (?) of China as *Neofusulinella praecursor* var. *pusilla*, and another species as *N. phairayensis* from the Permian of French Indo-China, which may be referable to the same genus. Lange (1925) described and illustrated two forms from the Middle Permian of western Sumatra and correctly referred them to *Schubertella* as *S. simplex* and *S. plana*. Ozawa (1925, pl. 9, fig. 9*b*) illustrated a representative of *Schubertella* from the Permian of Nagato as *Neofusulinella* sp., and later (1927) described and illustrated from the Permian at Akasaka two representatives of *Schubertella* as *Neofusulinella giraudi* Deprat and *N. simplex* (Lange), and another possibly congeneric form from the same region as *N. phairayensis* Colani. Ozawa and Tobler (1929) described and illustrated a representative of *Schubertella* from the Middle Permian of Greece as *Depratella* sp. In 1934 Doutkevitch (*Geol. Pamir Acad, Sci. USSR*, vol. 8, pp. 62, 63, 65–71, pl. 1, figs. 1–5 [Russian]) described and illustrated four representatives of *Schubertella* from the Permian of Pamir.

Lee (1927) described and illustrated two minute forms from the Taiyuan series (Permian) of northern China as *Boultonia willsi* and *Neofusulinella* (?*Schubertella*) *chaoi*. The first of these forms, *B. willsi*, is the type of the genus *Boultonia* Lee and this genus apparently is very similar and presumably very closely related to *Schubertella*. The wall structure and development of the juvenarium of this form seem to be identical with those of the type of *Schubertella*, but

Lee has pointed out that the septal fluting in *B. willsi* extends completely across the shell in the outer volutions of mature forms. The second of these species, *N. chaoi*, is represented in Lee's collection by only one specimen, but this form does not seem to be referable to *Schubertella*.

Chen (1934) described and illustrated a form from the Swine limestone (Permian) of southern China as *Schubertella pseudoobscura* which apparently is referable to *Schubertella*. However, Chen described the spirotheca of this form as being composed of only a tectum. At the same time Chen described another minute form as *S. regularis* from the Swine limestone which apparently is referable to an unnamed genus. Gubler (1935) described and illustrated two representatives of *Schubertella* from the Permian of French Indo-China as *Schubertella* sp. and *Fusulinella* sp.

In addition to the eight representatives of *Schubertella* mentioned above from the Permian of Spitzbergen and Asia which have been described as distinct species or varieties and the several unidentified forms of the Permian of Asia and Europe, at least six minute forms have been described from the Lower Pennsylvanian of Europe, Asia, and North America and referred to the genus *Schubertella*. However, the internal structures of these Lower Pennsylvanian forms are not closely similar to the type of that genus and I am referring them below to the new subgenus *Eoschubertella*. So far as known the typical subgenus of *Schubertella* is restricted to the Permian, but its representatives occur throughout that system.

I take this opportunity to express my sincere thanks to Dr. Hubert G. Schenck for the opportunity to study this valuable material and for his permission to use it in this publication. Most of the specimens illustrated in this report are in the Stanford University Paleontological Type Collection, and duplicates are kept with my private collection.

SYSTEMATIC DESCRIPTIONS

Family FUSULINIDAE Möller
Subfamily SCHUBERTELLINAE Skinner
Genus SCHUBERTELLA Staff and Wedekind
Subgenus SCHUBERTELLA s.s.

Diagnosis.—Shell minute, fusiform to subcylindrical. Mature forms consist of four to six volutions, 0.5 to 1.5 mm. in length and 0.3 to 0.9 mm. in width. The form ratio typically is 1:1.5 to 1:2.5. The juvenarium is composed of one to two volutions, its form ratio is very small, and its axis of coiling is typically at a large angle to the axis of the outer fusiform volutions. Poles sharply pointed. Lateral slopes convex. Spirotheca composed of a tectum and a lighter inner layer which does not show alveoli. Septa very numerous and essentially unfluted throughout the length of the shell. In some forms slight fluting is observed in the extreme polar regions of the outer volutions. The tunnel is low, rather broad, and is bordered by low asymmetrical chomata.

Representatives of *Schubertella s.s.* may be distinguished from those of the Lower Pennsylvanian genus *Fusiella* Lee and Chen and the new subgenus *Eoschubertella* mainly by the difference in their spirothecal structures. In *Schubertella* the spirotheca is composed of a tectum and a

"diaphanotheca," whereas in *Fusiella* the spirotheca is composed of one primary layer covered on its upper and lower surfaces with tectoria. Also, the type of *Fusiella* has a very small form ratio. *Schubertella* differs from *Fusulinella* Möller in the development of its juvenarium, its spirothecal structure, and its very poorly developed chomata. The only differences which can be pointed out at the present time between representatives of *Schubertella* and those of *Boultonia* Lee are that in *Boultonia* the septa are fluted completely across the shell in the outer volutions of mature forms and the shell of *Boultonia* typically has a much smaller form ratio.

Schubertella is very closely similar and undoubtedly very closely related to *Yangchienia* Lee. However, representatives of *Yangchienia* can be distinguished from those of *Schubertella* by their unusually well-developed chomata. Representatives of *Schubertella* and *Yangchienia* are found associated in the same limestone in several regions, but *Yangchienia* apparently is a descendant of *Schubertella*.

Neofusulinella lantenoisi Deprat, the genotype of *Neofusulinella* Deprat, and *N. phairayensis* Colani did not enter into the above diagnosis of *Schubertella s.s.* These two forms may possibly be congeneric but at least *N. lentenoisi* is not congeneric with *S. transitoria*. The large size, thick spirotheca with "réseau alvéolaire," and the different structure of the juvenarium and development of the volutions of *N. lantenoisi* serve to distinguish representatives of *Neofusulinella* from those of *Schubertella*.

Skinner (1931) has suggested the subfamily name Schubertellinae for the primitive Lower Pennsylvanian forms which I am referring to the new subgenus *Eoschubertella* and for representatives of *Fusiella*. Since we now know that the subgenus *Schubertella s.s.* is quite different from these Lower Pennsylvanian forms, the subfamily Schubertellinae should be emended to include the group of Permian fusulinids *Schubertella*, *Neofusulinella*, *Boultonia*, and *Yangchienia*, and the Upper Carboniferous forms of *Fusiella* and the subgenus *Eoschubertella*.

SCHUBERTELLA (SCHUBERTELLA) TRANSITORIA Staff and Wedekind
Plate 22, figures 1, 3–6

Schubertella transitoria STAFF and WEDEKIND, *1910*, Upsala Univ., Geol. Inst., Bull., vol. 10, p. 121, pl. 4, fig. 8, [not? fig. 7].
Schubertella cf. *transitoria* HOLTEDAHL, *1913*, Vidensk. selsk. I Kristiania 1912, I. Math.-naturh. Kl., no. 23, pp. 5, 9.

Shell minute, fusiform. Poles very sharply pointed. Lateral slopes steep and uniform. The central portion of the shell is somewhat inflated. Mature forms consist of five volutions, about 0.85 mm. in length and 0.42 mm. in width. The form ratio is about 1:2 for mature individuals of five volutions, but it is about 1:1.7 for the fourth volution and 1:1.3 for the third volution.

The spirotheca is composed of a tectum and a lighter rather thick inner layer which does not show any trace of alveoli. The spirotheca increases in thickness from an extremely thin layer in the first volution to about 5μ in the third volution, 9μ in the fourth volution, and 14μ in the fifth volution.

The septa are numerous and the septal count gives 8 to 11 for the first volution, 10 to 12 for the second volution, 14 to 15 for the third volution, and 15 for the fourth volution. The septa are thin and they are composed of the downward deflection of the tectum and a lighter layer on their posterior side which appears to be the downward extension of a part of the diaphanotheca. Also, the diaphanotheca extends a short distance down the anterior side of the septa. The septa are apparently unfluted throughout the length of the shell, but in the extreme polar regions of the outer volutions of some specimens the septa appear to be broadly fluted.

The proloculum is essentially spherical and its inside diameter measures 20 to

35μ. The innermost volution of this form has a form ratio of about 1.7:1 and its axis of coiling is almost normal to the axis of the outer fusiform volutions. The rate of increase of the height of the volutions is essentially uniform, and the heights of the first five volutions measure about 17, 26, 32, 49, and 67μ.

The tunnel is low and narrow. The tunnel angle measures about 17 degrees in the fifth volution. The line of intersection of the tunnel with axial sections is slightly irregular. The chomata are asymmetrical and they are well developed only in the fourth and fifth volutions. In the fifth volution the chomata are approximately one-half as high as the chambers and they extend about one-fourth the distance to the poles.

Remarks.—This species was originally based by Staff and Wedekind on two distinct types of specimens which were regarded by them as dimorphic representatives of the same species. One of these types has a relatively large proloculum, apparently is composed of only two volutions, and has a larger form ratio (see their pl. 4, fig. 7). The other type of specimens which was originally included in this species by Staff and Wedekind (see their pl. 4, fig. 8) has a very small proloculum, a smaller form ratio, and is composed of four to five volutions. The above description of this species is based entirely on specimens of this second type.[1] One poorly oriented section which apparently belongs to this first ("makrosphärischen") type of Staff and Wedekind is present in the same slide with some of the specimens described above (pl. 22, fig. 2) but it seems to me that it is not conspecific with these ("mikrosphärischen") specimens. I am regarding the specimen (or specimens) illustrated by Staff and Wedekind's figure 8 of their plate 4 as typical of *S. transitoria*. In the "makrosphärischen" form the proloculum is much larger and the inner volutions are essentially symmetrical. However, this type of specimen seems to be relatively rare. If these are to be considered the megaspheric form of a dimorphic species, this case is not in harmony with the opinions of several paleontologists who have cited cases which they thought represented dimorphism among fusulinids and in which the so-called microspheric forms have been reported very rare in comparison with the megaspheric forms.

[1] Staff and Wedekind's illustration of this second type of specimen does not show an endothyroid juvenarium and the juvenarium is illustrated as being almost symmetrical with the outer volutions. However, in their diagnosis of the genus they state "inneren Windungen endothyrisch." Specimens as represented by their pl. 4, fig. 7 could not conceivably possess an endothyroid juvenarium. We must then assume that their generic diagnosis is based on this second type of specimens. Their illustration (pl. 4, fig. 8) of this type is a drawing and possibly is a general composite of several sections and the juvenarium is not correctly drawn. Also, it should be pointed out that my specimens of an equal number of volutions are slightly larger than Staff and Wedekind's, as determined from their stated magnification, but they gave the magnification of their illustrations as being only approximate.

EXPLANATION OF PLATE 22

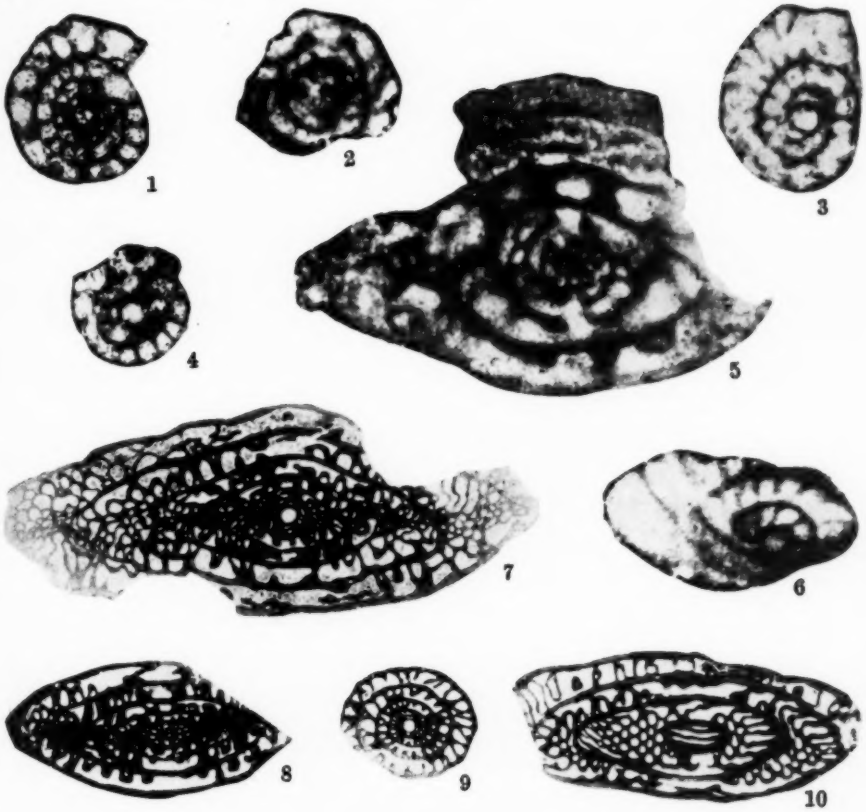
(All illustrations on this plate are unretouched photographs)

FIGS. *1, 3–6*—*Schubertella transitoria* Staff and Wedekind. *1, 3, 4*, Sagittal sections; *5*, axial section; *6*, oblique parallel section. All ×83. Permian, Tempel Bay, Spitzbergen. (p. 121)

2—*Schubertella*(?) sp. Axial section, ×83. Permian, Tempel Bay, Spitzbergen. (p. 122)

7–10—*Schwagerina anderssoni* (Schellwien) (?). All ×10. Permian, Isfjord, Spitzbergen. (p. 123)

11—Section of bituminous Permian limestone from Tempel Bay, Spitzbergen, which contains *Schubertella transitoria*, showing numerous sections of *Schwagerina*(?) *artica* (Schellwien) and several sections of Foraminifera other than fusulinids, ×10. (p. 123)



Thompson, Permian Fusulinids

UNIV. OF MICH.

S. transitoria is very closely similar and presumably very closely related to *S. giraudi* (Deprat) of the Middle Permian of French Indo-China, and these two forms may possibly be conspecific. However, the Spitzbergen form apparently has a smaller form ratio, and the general development of the shell seems to be different from that of *S. giraudi*.

Occurrence.—The specimens on which the above description is based came from Tempel Bay, Spitzbergen (presumably from the fusulinid-bearing limestone discovered by Nathorst in 1882 in a gully on the southeast side of the bay) and at least part of Staff and Wedekind's original types probably came from the same exposure of limestone. Over 50 per cent of the limestone sample from which the specimens I am studying were obtained is composed of shells of *Schwagerina? arctica* (Schellwien) (pl. 22, fig. 11). Also, numerous sections of Foraminifera other than fusulinids are found in many of the thin sections of this same sample. A hand specimen labeled as coming from Isfjord, Spitzbergen, contains minute fusulinids which seem to be conspecific with the specimens from Tempel Bay and which are associated with *Schwagerina anderssoni* (Schellwien)? (see pl. 22, figs. 7–10). Also, Holtedahl (1913) reports a form as *Schubertella* cf. *transitoria* from the region west of Green Bay, Spitzbergen. The associated forms of *S. transitoria* indicate that it is Lower Permian in age.

Types.—Specimens illustrated on pl. 22, figs. 4 and 5 (both on same slide), Stanford Univ. Pal. Type Coll. No. 5942; fig. 7, No. 5943; figs. 8 and 9 (both on same slide), No. 5944; fig. 10, No. 5945. All other types are in M. L. Thompson Fusulinid Collection.

Subgenus EOSCHUBERTELLA Thompson, n. subgen.

Subgenotype: *Schubertella lata* Lee and Chen.

Diagnosis.—Shell minute, ellipsoidal to subglobular, loosely coiled. Mature forms consist of three to five volutions, 0.35 to 1.3 mm. in length and 0.3 to 0.7 mm. in width. The form ratio is 1:1.7 to 1:1.2. Juvenarium composed of one to one and one-half volutions, its axis of coiling may or may not be at a large angle to outer volutions, and its form ratio is typically small. Poles rounded to very bluntly pointed. Spirotheca composed of tectum, diaphanotheca, and upper and lower tectoria. Diaphanotheca typically very thin and cannot be recognized in most sections. The septa are thin and they are essentially unfluted throughout the length of the shell. The tunnel is rather narrow and the chomata are well developed but they are typically small.

Mainly on the basis of the spirothecal structure, I (1935, 1936) formerly suggested that the minute fusulinids from the Lower Pennsylvanian of Asia, Europe, and America which belong to the general group usually referred to *Schubertella* should be included in the genus *Fusulinella*. These minute forms, however, are much smaller, normally have fewer volutions, are shorter and more nearly globular, and have relatively more highly inflated chambers than typical *Fusulinella*. Practically all students of Lower Pennsylvanian fusulinids have recognized that these minute forms represent a rather definite group but few have been able to recognize the four layers of the spirotheca. Probably in most representatives of this genus the diaphanotheca cannot be differentiated from the tectum. Our studies of the fusulinids have progressed to the point where it seems advisable to separate these minute forms into a separate group, even though it is recognized that they are somewhat closely related to *Fusulinella* as well as *Schubertella s.s.* With the true nature of the type of *Schubertella s.s.* now known, we are able to divide the minute fusulinids of the Pennsylvanian and Permian with more confidence into separate genera and subgenera.

The following forms seem more closely related to *Schubertella* (*Eoschubertella*) *lata* (Lee and Chen) than to any other recognized subgenotype and hence I am

referring them to the subgenus *Eoschubertella: Schubertella obscura* Lee and Chen, *S. magna* Lee and Chen, *S. gallowayi* Skinner, *Fusulinella oliviformis* Thompson, *F. diminutiva* Thompson. All of these species come from strata equivalent in age to our American Lower Pennsylvanian.

Through the kindness of Dr. J. S. Lee I have had the opportunity to examine part of the original figured types of the genotype of *Fusiella* Lee and Chen, *F. typica* Lee and Chen, and the only layers which can be recognized in the spirotheca of these types are a thin inner dark central layer and outer layers of tectoria. However, as was pointed out by Lee and Chen (1930), the spirothecal structure is somewhat blurred in these sections. It seems evident that the dark layer in the middle of the spirotheca of *Fusiella typica* corresponds to the tectum and diaphanotheca of such forms as *Staffella* and *Fusulinella*. The primitive development of the juvenarium and the weak chomata in *Fusiella*, however, distinguish representatives of this genus from those of the more highly developed forms of *Fusulinella*. *Fusiella granum-oryzae* Doutkevitch of the Middle Carboniferous (Lower Missouri series) of western European Russia is apparently the most highly developed representative of *Fusiella* so far described. Doutkevitch's (1934) very thorough description and illustrations of this form suggest that in the outermost volution of mature individuals a thin diaphanotheca is becoming visible (see his pl. 1, fig. 8). This species is probably an ancestral form of *Boultonia* Lee. Representatives of *Fusiella* may be distinguished from those of *Eoschubertella* by their more compact coiling, more elongate shells, and marked difference in the profiles of the different volutions. Both of these groups have rather primitive juvenaria and their spirothecal structure is also primitive. Our present meager knowledge of the primitive fusulinids suggests to me that *Eoschubertella* was ancestral to the Lower Pennsylvanian genus *Fusulinella*, and its more primitive branch gave rise to *Fusiella*. The main stock of *Eoschubertella* apparently remained little changed along side of more advanced fusulinids and in Lower Permian times gave rise to *Schubertella s.s.*

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MIDDLE PERMIAN FUSULINIDS FROM SZECHUAN, CHINA

M. L. THOMPSON and C. L. FOSTER

ABSTRACT

The Yanghsin limestone of the Mt. Omei region, China, is divisible into three units which we refer, respectively, to the Moscovian(?), Lower Permian, and Upper Permian. In this paper eleven species of fusulinids are described and illustrated from the upper unit of the Yanghsin limestone, and they are referred to the genera *Schubertella*, *Neofusulinella*, *Ozawainella*, *Staffella*(?), *Schwagerina*, *Eoverbeekina*, *Verbeekina*, *Pseudodoliolina*, *Neoschwagerina*, and *Sumatrina*. The following forms are described as new: *Eoverbeekina cheni*, *Verbeekina grabaui*, and *V. heimi*.

Several reports have been published in recent years on the geology of the vicinity of Mt. Omei, on the southwestern edge of the Red Basin, Szechuan Province, China, but very little paleontological work of a systematic nature has been published on the rich faunas found in many of the sedimentary rocks of that part of China. Foster (1923) has discussed rather briefly the stratigraphy and structure of this region, giving a list of fossils collected about 5 miles east of Mt. Omei from strata which he considered Upper Carboniferous or Permian in age. Chao (1929) worked out the general stratigraphic section for the Mt. Omei region and proposed names for the larger lithologic units. Heim (1932) discussed at some length the structure of the Mt. Omei area and summarized the stratigraphy of the region as known up to that time.

The general structure of the immediate region around Mt. Omei is a double-plunging anticline, known as the Omeishan Anticline, with the axis trending north-south. The western limb of the anticline has a dip of 10 to 25 degrees. The dip on the eastern limb varies considerably from place to place and the region is cut by numerous faults. The dip of the east limb varies from 10 to more than 90 degrees. The eastern and central portions of the Omeishan Anticline have been very highly dissected by stream erosion into peaks, ridges, and canyons. The western side of the anticline is little eroded and it forms the very prominent hogback known as Mt. Omei, which is bounded on the east by an almost vertical cliff over 3,000 feet high and which has a westward sloping surface of 10 to 25 degrees.

The following stratigraphic names have been used for the strata exposed within the Omeishan Anticline, the youngest at the top.

Stratigraphic Divisions Exposed within the Omeishan Anticline

	Thickness (feet)
9. Coal-bearing series (Jurassic)	800
8. Purple shale and limestone (Triassic)	2,750
7. Omeishan basalt (Permian?)	1,000–1,300
6. Yanghsin limestone (Permian)	650–1,300
5. Shinkaisze (Silurian)	420– 550
4. Hsihsiangtshi (Ordovician?)	550– 700
3. Yusiensze series (Cambrian)	200– 230
2. Tshiulaotung series (Cambrian?)	500– 800
1. Hungtshungping limestone (Sinian)	3,600–4,000

During five summer field seasons, 1919 to 1923 inclusive, the junior author of the present paper obtained rather large collections from the Yanghsin limestone near the bungalows of the summer resort about 5 miles east of the eastern cliff of Mt. Omei. Among these collections there are a number of hand-specimens of limestone which contain an abundance of fusulinids, and the fusulinids seem to offer the best available clues as to the age of the limestone. The following systematic fusulinid study is based entirely on the collections mentioned.

Foster (1923), who listed "*Schwagerina* sp." from the middle portion of the Yanghsin limestone, apparently was the first to report fusulinids from near Mt. Omei. From the lower part of the Yanghsin limestone on the Mt. Omei trail Chao (1929) reported *Fusulinella*, and from the upper part *Schwagerina*, *Fusulina*, and *Neoschwagerina*. Heim (1932) added that fusulinids are abundant in the middle part of the limestone. Thompson and Miller (1935) described *Schwagerina fosteri*, probably from the middle portion of the Yanghsin limestone on the eastern slope of Shin K'ai Shi, an erosional remnant on the eastern limb of the Omeishan Anticline. *S. fosteri* is referable to the newly established genus *Paraschwagerina* Dunbar and Skinner and that species indicates Lower Permian age for at least part of the Yanghsin limestone.

The genus *Fusulinella* Möller is believed to be restricted to the lower portion of the Upper Carboniferous (Moscovian), even though it has been identified from the Upper Permian of Japan and from the Middle Permian of Sicily and Greece, the identification from one of these localities being certainly in error and the others probably erroneous. If Chao's identification of *Fusulinella* from Mt. Omei is correct, the lower portion of the Yanghsin limestone may be equivalent in age to the Huanglung limestone (Moscovian) of eastern China. It should be mentioned in this connection, however, that *Neofusulinella lantenoisi* Deprat, of which we have numerous sections, very closely resembles *Fusulinella* in general outline, and Chao may have been studying this form. Chao's specimens have not been described or illustrated. The forms identified by Chao as *Schwagerina*, *Fusulina*, and *Neoschwagerina*, from the upper portion of the Yanghsin limestone, all clearly indicate Permian age for that part of the formation.

Because of variation in dips and the presence of several faults, it is difficult to determine in every case from exactly what position in the Yanghsin limestone all of our collections were obtained. Heim has recognized three lithologic units of the Yanghsin limestone but he has not proposed member names for them. On the eastern cliff of Mt. Omei the lower unit is estimated to be about 140 feet thick, the middle unit about 140 feet thick, and the upper unit about 390 feet thick. In the eastern portion of the Omeishan Anticline the Yanghsin limestone reaches an estimated thickness of about 1,300 feet.

The basal part of this limestone, from which Chao reports *Fusulinella*, is overlain by an irregular bed of black shale. Apparently none of our collections came from this lower unit.

As nearly as we have been able to determine, the fusulinids which we are studying were collected from the Yanghsin limestone as follows: *Paraschwagerina fosteri* (Thompson and Miller) from the middle unit of the Yanghsin limestone (about 300 feet above the base of the formation) near the Foster Bungalow; *Neofusulinella lantenoisi* Deprat, *Ozawainella* sp., and *Eoverbeekina cheni*, n. sp., from the lower portion of the upper unit from near the Foster Bungalow and from near the Wellwood Bungalow; *Schubertella simplex* Lange, *Verbeekina grabaui*, n. sp., *Pseudodoliolina pseudolepida* (Deprat), *Neoschwagerina* aff. *N. carticulifera* (Schwager) from the upper unit of the formation (probably near the mid-portion of the unit) about 500 feet east of the Davies Bungalow; and *S. simplex* Lange, *Staffella*(?) sp., *Schwagerina* sp., *Verbeekina heimi*, n. sp., and *Sumatrina annae* Volz (?) from the upper portion of the Yanghsin limestone near the Foster Bungalow and on the cliff below the Davies Bungalow.

Our study of the fusulinids of the Yanghsin limestone indicates clearly that the upper portion of the formation is Middle Permian in age, and its fusulinid fauna seems to be rather closely related to at least a part of the fusulinid fauna of the Chihsia limestone of southeastern China, of the Permian limestone of Guguk Bulat, Sumatra, of the Sosio beds of Sicily, and of the Permian of the Aegean Islands, Greece. The fusulinids of the lower portion of the upper unit of the Yanghsin limestone may also be Middle Permian in age, but if they are Middle Permian, they are probably lower Middle Permian. Thompson and Miller (1935) suggested the correlation of the horizon of *Paraschwagerina fosteri* with the Taiyuan series of northern China and the Big Blue series and the Wolfcamp formation of North America. It seems to us that the horizon of *P. fosteri* is Lower Permian in age, but we doubt that it is lowermost Lower Permian.

Lee and Chao (1924) have listed three fusulinids from the Lower Wushan limestone of the Yangtze Gorge as "*Fusulinella multivoluta* sp. nov., *Fusulinella verbeekinoides* sp. nov., and *Fusulinella sphaerica* Abich." The first two of these names are *nomina nuda*, and Lee and Chao illustrated none of these forms. It is clear, however, that Lee (1933) later described and illustrated one of them as *Pisolina excessa* Lee, another as *Nankinella orbicularia* Lee, and he referred the form identified in 1924 as *Fusulinella sphaerica* Abich to *Eoverbeekina intermedia* Lee. The horizon of these forms in the Lower Wushan limestone probably is not greatly different in age from the horizon of *Eoverbeekina cheni*, *Ozawainella* sp., and *Neofusulinella lantenoisi* described below from the Yanghsin limestone. In their report of 1924, mentioned above, Lee and Chao identified two forms from the Upper Wushan limestone as *Yabeina inouei* Deprat and *Neoschwagerina margaretae* Deprat. The Middle Wushan limestone is considered to be definitely Middle Permian in age, but the horizon of these two highly developed fusulinid species is probably younger stratigraphically than any of our Yanghsin forms.

SYSTEMATIC DESCRIPTIONS

Family FUSULINIDAE Möller
Subfamily SCHUBERTELLINAE Skinner

Genus SCHUBERTELLA Staff and Wedekind

Subgenus SCHUBERTELLA Staff and Wedekind (*s.s.*)

Thompson (1937) has recently studied the subgenotype of *Schubertella* (*s.s.*), *S. transitoria* Staff and Wedekind, from Spitzbergen, and found that it is Permian in age and that its spirotheca is composed of a tectum and an apparently structureless lower layer which is referred to as a diaphanotheca. Our form described below as *Schubertella* (*Schubertella*) *simplex* Lange clearly is congeneric with *S. transitoria*. The subgenus *Schubertella* is represented by about ten described species and it occurs throughout the Permian.

SCHUBERTELLA (SCHUBERTELLA) SIMPLEX Lange

Plate 23, figures 5–11

Schubertella simplex LANGE, *1925*, Geol.-mijnb. genootsch Nederland en Kolonien, Verh., Geol. ser., Deel 7, pp. 254, 255, pl. 3, figs. 60*a*–60*d*.

(?) *Neofusulinella simplex* OZAWA, *1927*, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2 (Geology), vol. 2, pt. 3, p. 151, pl. 39, fig. 8.

Fusulinella simplex YABE and HANZAWA, *1931*, Leidsche Geol. Mededeel., Deel 5 (Feestb. K. Martin), p. 25.

Shell very minute, subellipsoidal. Mature specimens consist of about five volutions and they measure about 0.65 mm. in length and 0.4 mm. in width. The form ratio is about 1:1.6. The profile of the first volution is subcircular and in the second and third volutions the profile becomes elliptical. The lateral slopes of mature specimens are moderately low and are distinctly convex. Poles very blunt to broadly rounded.

The spirotheca of this species is relatively very thick. It is composed of a tectum and thick lighter inner layer which does not show any traces of alveoli. The spirotheca increases in thickness from an extremely thin layer in the first volution to 5μ in the second volution, 12μ in the third volution, 21μ in the fourth volution, and 27μ in the fifth volution.

The septa are rather thick and they are formed by the downward deflection of the tectum and diaphanotheca of the spirotheca. The diaphanotheca thins markedly toward the base of the septa. There are 8 septa in the second volution, 11 in the third volution, and 16 in the fourth volution. The septa are unfluted throughout the length of the shell.

The proloculum is very small and its inside diameter measures about 35μ. The first volution has a form ratio of about 1:0.53 and its axis of coiling is almost normal to the axis of coiling of the outer volutions. The rate of expansion of the shell is essentially uniform and the heights of the first five volutions are 21, 30, 48, 60, and 85μ.

The tunnel is broad and it is about one-half as high as the chambers in the fifth volution. The tunnel angle measures about 35 degrees in the fifth volution. Chomata are extremely small or absent.

Remarks.—*Schubertella simplex* resembles in some respects *S. transitoria* Staff and Wedekind. These two species may be distinguished rather easily, however, for in *S. simplex* the shell expands more rapidly, the spirotheca is thicker, the tunnel angle larger, and the chomata much smaller. Also, the shells of these two forms have different shapes. *S. simplex* resembles *S. giraudi* (Deprat) in some respects, but it is smaller, has thicker spirotheca, a larger tunnel angle, and its shell is different in shape than that of *S. giraudi*.

Occurrence.—This species was originally described by Lange from the Middle Permian of Guguk Bulat, Sumatra. Ozawa referred specimens to this species from the Permian of Akasaka, Japan. It is very abundant in a light-gray dense limestone, about 1⅛ miles east of Shin K'ai Shi, where it is associated with *Sumatrina annae* Volz (?), *Staffella* (?)

sp., *Schwagerina* sp., and *Verbeekina heimi*, n. sp., and it is rather abundant in a medium-gray slightly cherty limestone, about 1 mile east of Shin K'ai Shi and 500 feet east of the Davies Bungalow, where it is associated with *Neoschwagerina* aff. *N. carticulifera* (Schwager), *Pseudodoliolina pseudolepida* (Deprat), and *Verbeekina grabaui*, n. sp.

Genus NEOFUSULINELLA Deprat, 1912

The genus *Neofusulinella* was established by Deprat (1912) for an unnamed species from the Middle Permian of French Indo-China. The following year Deprat (1913) described this species as *Neofusulinella lantenoisi* and at the same time referred two other species, *N. praecursor* Deprat and *N. schwagerinoides* Deprat, to this genus, but he did not designate a genotype. It is clear from his original description of *Neofusulinella*, however, that it was based entirely on *N. lantenoisi* and that the other two species referred to it in 1913 did not enter into the description. *N. lantenoisi*, therefore, must be regarded as the genotype of *Neofusulinella* (Thompson, 1934).

Deprat's illustrations of *N. lantenoisi* are partially, at least, drawings, and the types have apparently been irretrievably lost. Much uncertainty has been expressed by several paleontologists as to the precise nature of this species. Deprat's figure 23 on his plate 7 (apparently a retouched photograph), however, shows many of the major characters of this form. We have a number of sections of a form in our collections which possess characters that seem to be identical with the characters of the types of *N. lantenoisi* as determined from Deprat's description and illustrations. We are, therefore, referring our form to that species.

So far as we have been able to determine, the genotype is the only described representative of *Neofusulinella*. The generic diagnosis is given below under the description of *N. lantenoisi*.

Neofusulinella is more closely similar and presumably more closely related to *Yangchienia* Lee than to any other recognized genus. The major differences between these two genera are that in *Yangchienia* the juvenarium is endothyroid and asymmetrical, its chomata are much better developed, and the spirotheca is much thinner than in *Neofusulinella*. *Neofusulinella* apparently is closely related to *Schubertella* and it may have developed from that genus. It is typically much larger, has a markedly different juvenarium, and its spirotheca is thicker and has a different structure from that of *Schubertella*. In many respects *Neofusulinella* resembles representatives of *Triticites* Girty but these two genera are undoubtedly quite distinct biologically. The septa of *Neofusulinella* are not fluted in the same manner as those of *Triticites*, its spirotheca is typically thinner, its chomata are not similar to those of *Triticites*, and its shell is smaller at maturity than in most specimens of *Triticites*.

Neofusulinella has been placed in

EXPLANATION OF PLATE 23

All illustrations on this plate are unretouched photographs. All specimens are from the Yanghsin limestone on Shin K'ai Shi, Szechuan, China.

FIGS. *1–3*—*Verbeekina heimi* Thompson and Foster, n. sp. Sections of sub-mature individuals, ×10. (p. 137)

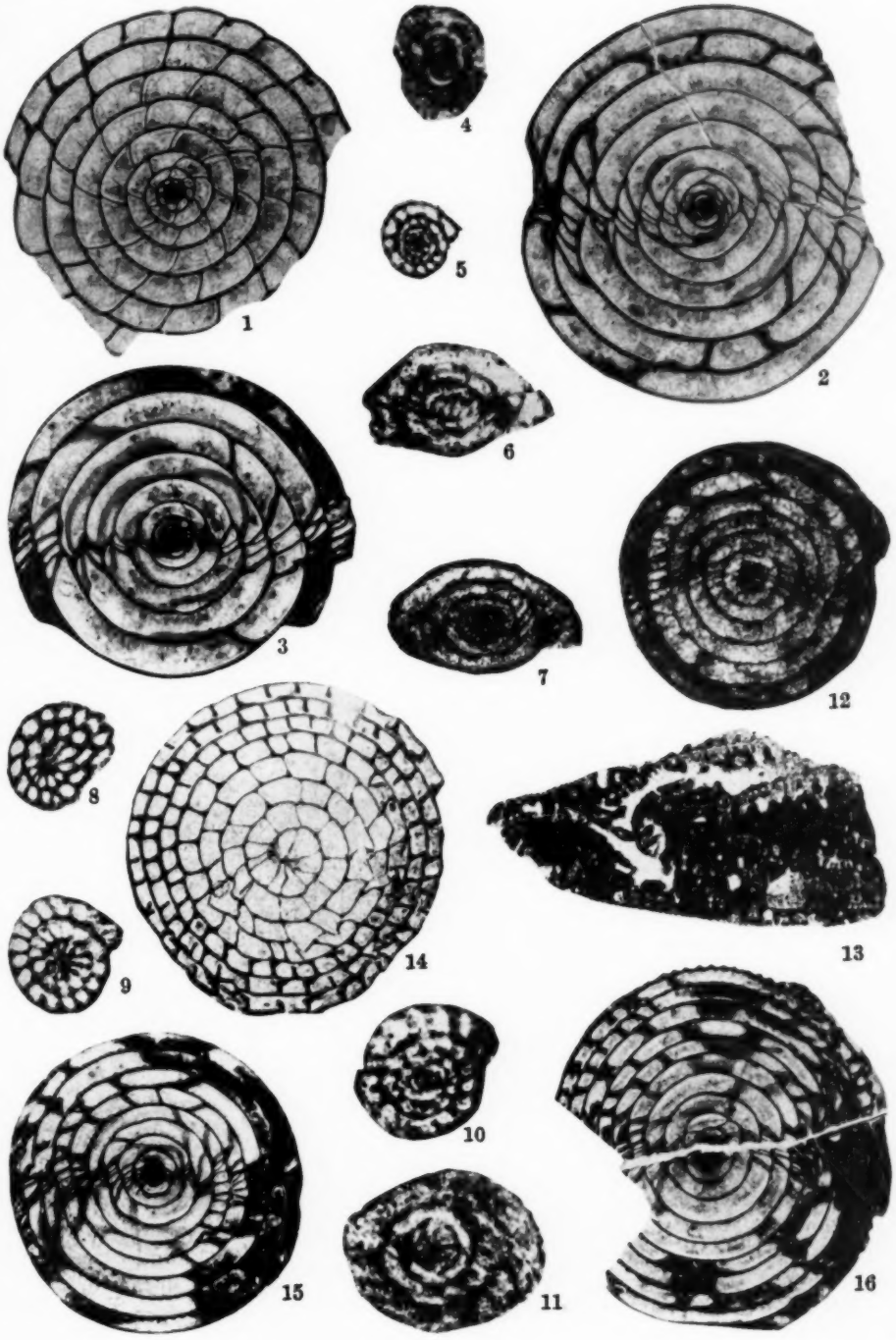
4—*Staffella*? sp. Axial section, ×40. (p. 134)

5–11—*Schubertella simplex* Lange. *5*, *10*, Sagittal sections, ×40. *6*, *11*, Oblique sections, ×40. *7*, Axial section, ×40. *8*, *9*, Parallel sections, ×40. (p. 129)

12—*Eoverbeekina cheni* Thompson and Foster, n. sp. Tangential section, ×10. (p. 135)

13—*Sumatrina annae* Volz?. Portion of a tangential section, ×20. (p. 143)

14–16—*Verbeekina grabaui* Thompson and Foster, n. sp. *14*, Parallel section, ×10. *15*, *16*, Axial sections, ×10. (p. 136)



Thompson and Foster, Permian Fusulinids

UNIV. OF MICH.

synonymy with *Fusulinella* Möller, *Schubertella* Staff and Wedekind, and *Depratella* Ozawa. It has been considered Permian in age by some, and Moscovian (Lower Pennsylvanian) in age by others. The genotype and only known representative is Middle Permian in age.

NEOFUSULINELLA LANTENOISI Deprat
Plate 24, figures 1–4

Neofusulinella sp., DEPRAT, *1912*, Acad. sci. Paris, Comptes rendus, tome 154, pp. 1549, 1550.

Neofusulinella lantenoisi DEPRAT, *1913*, Indochine Service géol., Mém., vol. 2, fasc. 1, pp. 41, 42, pl. 7, figs. 23–25.

Shell small, short, obese, fusiform. Poles sharply pointed. Lateral slopes steep and uniform. Mature forms consist of five to six volutions and they measure 2.8 to 3.7 mm. in length and 1.8 to 2 mm. in width. The form ratio is large in the inner one to two volutions and it is about 1:1.8 for the fifth and sixth volutions.

The spirotheca is relatively thick and it is composed of a tectum and a thick lower layer. The finer details of the structure of the spirotheca have been blurred by replacement during fossilization, as seen in some sections, but there are faint indications of an alveoli-like structure in the lower layer. Near the center of the shell the spirotheca measures about 30, 40, 60, and 70μ, respectively, in the third to the sixth volutions. Poleward from the tunnel the spirotheca thins very rapidly.

The septa are rather numerous. They are composed of the tectum and a lighter layer on the posterior side. The anterior side of the septa are covered by a layer which has been altered to the point where its exact nature cannot be determined. It may be continuous with the chomata. The septal count gives about 18, 20, 24, and 32 for the third to the sixth volutions. The septa are very straight across the mid-portion of the shell and they are essentially unfluted throughout the length of the shell.

None of our sections are well enough centered to measure the diameter of the proloculum. All volutions are essentially symmetrical throughout the shell. The inner volution is rather tightly coiled but the rate of expansion is uniform and the outer volutions are highly inflated. The heights of the second to the sixth volutions of a typical specimen measure 70, 100, 130, 170, and 240μ, respectively.

The tunnel is very narrow in the inner volutions but in the sixth volution it is low and wide and there it is about one-seventh as high as the chambers and about one-tenth as high as wide. The tunnel angle measures about 30 degrees in the sixth volution. The chomata are well developed throughout the shell. They are almost one-half as high as the chambers in the fifth volution of forms of six volutions. The tunnel side of the chomata are essentially vertical and the chomata slope downward very rapidly toward the poles.

Remarks.—The specimens which we are studying agree remarkably closely with Deprat's illustrations of the syntypes as well as his descriptive data of the genotype of *Neofusulinella, N. lantenoisi.* The following characters of our specimens are almost identical with those of Deprat's illustrated and described syntypes: the size and number of volutions, the shape of the shell, the rate of expansion and heights of the different volutions, the tunnel angle, the size and shape of the chomata, the thickness of the spirotheca, the structure of the spirotheca, the septal count, and the attitude of the septa. It therefore seems certain that our specimens are conspecific with Deprat's syntypes of *N. lantenoisi.*

This species is the only described representative of *Neofusulinella*, and it is so distinct from all other described fusulinids that specific comparisons seem unnecessary.

Occurrence.—Deprat's types came from the Permian limestone of Bam-Na-Mat, between Sam-Neua and Luang-Prabang, where they are associated with *Schwagerina ? parumvoluta* (Deprat), *Doliolina major* Deprat, and *Cancellina neoschwagerinoides* (Deprat). This species

occurs rather abundantly in a dark-gray to black, slightly cherty limestone, about a quarter of a mile east of Shin K'ai Shi near the Wellwood Bungalow, where it is associated with *Eoverbeekina cheni*, n. sp., and *Ozawainella* sp.; and in a dark-gray to black, slightly cherty limestone about 1⅛ miles east of Shin K'ai Shi near the Foster Bungalow, where it is associated with *Ozawainella* sp.

Subfamily Ozawainellinae Thompson and Foster, n. subfam.

Genus Ozawainella Thompson, 1935

The genus *Ozawainella* was established by Thompson (1935) with *Fusulinella angulata* Colani as genotype. It belongs to the general group of lenticular and discoidal fusulinids which have at various times been referred to *Fusulinella* Möller, *Staffella* Ozawa, and *Nankinella* Lee, and to the questionable fusulinid genera *Orobias* Eichwald (=*Ozawaina* Lee) and *Nummulostegina* Schubert. The available evidence indicates that in Lower Carboniferous (Mississippian) times the lenticular forms of the group to which *Fusulinella struvii* Möller belongs and the Middle Carboniferous (Lower Pennsylvanian) spheroidal forms generally referred to *Staffella* were developed from a common ancestor. The latter type gave rise to the fusiform and ellipsoidal to spheroidal fusulinids, and the former type gave rise to the discoidal and lenticular fusulinids of the Upper Carboniferous and Permian. The relationship between *Ozawainella* and the highly developed fusiform and ellipsoidal to spheroidal fusulinids of the Permian seem, therefore, to be rather far removed.

Our present knowledge of the development of the lenticular and discoidal fusulinids during the Carboniferous and Permian is rather meager, but they seem to constitute a rather definite group and do not seem to fit well within any previously defined subfamily of the Fusulinidae. If subfamilies of the fusulinids are to be recognized, it seems to us that a new subfamily should be established for the Carboniferous forms now generally referred to "*Orobias*" and "*Nummulostegina*" and the Permian fusulinids of the genera *Nankinella* and *Ozawainella*. We are, therefore, proposing the subfamily name Ozawainellinae for them. We would have preferred to use the older genus *Nankinella* Lee for the type of this subfamily, but *Ozawainella* seems to be more primitive biologically and more typical of the group, and we have had the opportunity to study first-hand specimens of *Ozawainella*.

The spirotheca of *Ozawainella* is composed of a tectum and a lower layer which we are referring to as a keriotheca, the minute structures of which have not been clearly observed. The periphery is sharply angular to subangular. The tunnel is narrow and high and more or less triangular in cross section. The chomata are well developed and they spread laterally almost to the poles. The septa are thin and numerous, and they are unfluted throughout the shell. The

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Explanation of Plate 24

All illustrations on this plate are unretouched photographs. All of the specimens are from the Yanghsin limestone on Shin K'ai Shi, Szechuan, China, except those of figures 9 and 10 which are from the Nezumi zone of the Akasaka limestone, Akasaka, Mino, Japan.

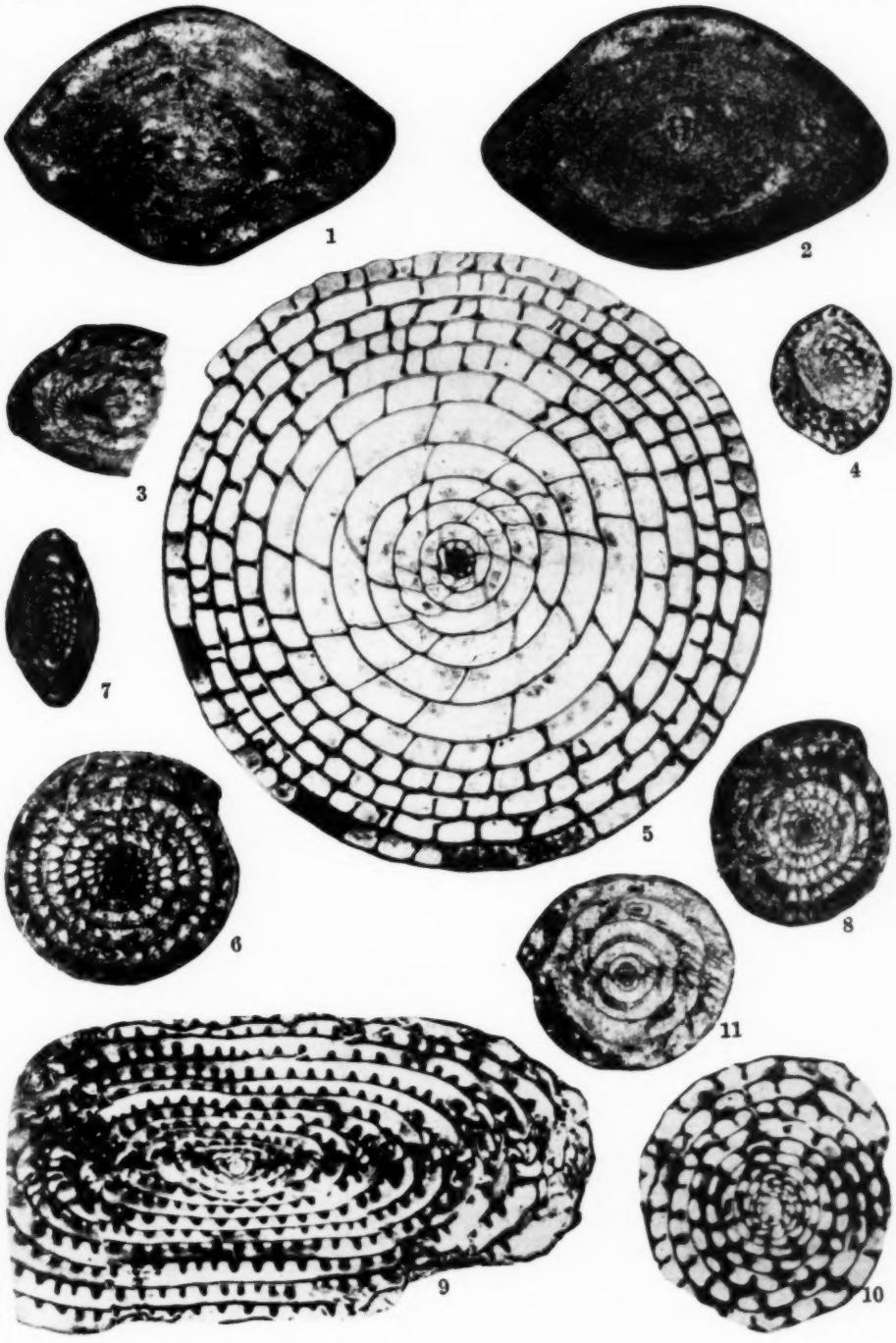
Figs. *1–4*—*Neofusulinella lantenoisi* Deprat. *1, 2*, Slightly tangential sections, ×20. *3*, Portion of a tangential section, ×10. *4*, Crushed sagittal section, ×10. (p. 131)

5—*Verbeekina heimi* Thompson and Foster, n. sp. Sagittal section, ×10. (p. 137)

6–8—*Ozawainella* sp. *6, 8*, Sagittal sections, ×10. *7*, Oblique section, ×10. (p. 133)

9, 10—*Pseudodoliolina ozawai* Yabe and Hanzawa. *9*, Axial section, ×20. *10*, Sagittal section, ×20. (p. 138)

11—*Eoverbeekina cheni* Thompson and Foster, n. sp. Axial section, ×10. (p. 135)



Thompson and Foster, Permian Fusulinids

UNIV. OF MICH.

axis of coiling is short and the form ratio is 2:1 to 4:1.

Schubert's illustrations of the type of *Nummulostegina* indicate a periphery which is rather broadly rounded. The exact nature of the internal structures of *Nummulostegina* is not clear to us, but the rounded periphery of this genus indicates that its representatives would not be confused with those of *Ozawainella*. The original illustrations of *Nummulina antiquior* Rouiller and Vosinsky, the genotype of *Orobias*, show a form which does not seem to be planispiral and of which the periphery is not sharply angular. This form is supposed to be conical at one end of the axis and almost flattened at the other end.

Through the kindness of Prof. C. O. Dunbar we have studied a sample of the white marly Mjatschkowo limestone from Mjatschkowo, Russia, collected by the late Prof. L. V. Pirsson. This material is rather easily crushed and the specimens are readily isolated. We have obtained from this sample numerous specimens of *Fusulina*, *Staffella*, and a small discoidal form which probably is referable to *Fusulinella bradyi* Möller. Mjatschkowo is the type locality of *N. antiquior* but we have not succeeded in finding specimens which resemble the illustrations or which conform to the description of that species. There are, however, small concretions or oölities of various shapes present in the material we are studying. It seems to us probable that Rouiller and Vosinsky's types of *N. antiquior* are not all fusulinids.

Ozawainella sp.
Plate 24, figures 6–8

Shell of medium size, lenticular in shape. Periphery subangular. Our largest specimens are composed of nine volutions, and they measure about 2 mm. in length and 4 mm. in width. The form ratio is slightly more than 1:0.5 for the ninth volution and it is essentially the same throughout the shell.

Septa very numerous. The septal count of the third to the ninth volution of a typical specimen gives 12, 15, 20, 22, 30, 36, and 35. The preservation of our specimens is such that the detailed structure of the septa cannot be determined with certainty. The septa are unfluted.

The proloculum is very small and its inside diameter measures about 40μ. The rate of expansion of the shell is uniform, and the heights of the first to the ninth volutions of a typical specimen measure 35, 60, 105, 130, 215, 233, 277, 285, and 260μ. The volutions are symmetrical throughout the shell.

The spirotheca is thick. It is composed of a tectum and a very thick lower layer. The preservation is such that the finer details of the spirothecal structure cannot be determined and alveoli have not been recognized. The tectum together with the lower layer of the spirotheca measures 17, 26, 43, 60, 87, 87, and 105μ in the third to the ninth volutions.

The tunnel is essentially triangular in cross section and it is developed almost to the end of the last volution. The chomata are well developed and they are markedly asymmetrical. The exact nature of the chomata are not clearly shown in all parts of our specimens.

Remarks.—Most of the characters of this form can be determined from the material of our collection, and it does not seem to be referable to any previously described species. Since the exact nature of the development of the chomata and the septal and spirothecal structures can not be determined with certainty from our specimens, we hesitate to make them the types of a new species. Although we have a rather large number of specimens, we do not feel sure that any of them are mature.

This species seems to be more or less an intermediate form between *Nankinella* Lee and *Ozawainella* Thompson. Colani's illustrations of the genotype of *Ozawainella*, *O. angulata* (Colani), show a spirotheca composed of a tectum and a relatively thick keriotheca. Also, *O.*

angulata has a rather sharply angular periphery and broad well developed chomata. The form we are studying has a more sharply angular periphery and apparently broader and better developed chomata than the type of the genus *Nankinella* Lee, *N. discoides* (Lee). In general shape the specimens we are studying resemble *Fusulinella terebra* Lange of the Middle Permian of Sumatra, but Lange's illustrations of that form do not permit detailed specific or generic comparisons.

Occurrences.—This form occurs rather abundantly in a dark-gray to black, slightly cherty limestone, about one-fourth of a mile east of Shin K'ai Shi near the Wellwood Bungalow, where it is associated with *Eoverbeekina cheni*, n. sp., and *Neofusulinella lantenoisi* Deprat, and in a dark-gray to black, slightly cherty limestone, about 1⅛ miles east of Shin K'ai Shi near the Foster Bungalow, where it is associated with *Neofusulinella lantenoisi* Deprat.

Subfamily FUSULININAE Staff and Wedekind

Genus STAFFELLA Ozawa

STAFFELLA? sp.
Plate 23, figure 4

We have found only one specimen of this form in our collections. Since it is incomplete and probably represents an immature individual, its specific as well as generic affinities can not be determined with certainty.

Our specimen is subspherical in shape and measures about 0.3 mm. in length and 0.38 mm. in width. It is composed of four volutions and it is slightly umbilicate. The form ratio is about 1:0.55 for the second volution and about 1:0.8 for the fourth volution. The periphery is rounded throughout the shell. The spirotheca is relatively thick and it is apparently composed of a tectum and a light inner layer. The spirotheca measures about 17.5μ in the fourth volution. The tunnel is rather low and narrow and its line of intersection with axial sections is essentially straight. The chomata are narrow but well developed. The proloculum measures about 25μ in diameter.

Remarks.—The general shape of the shell and the development of the chomata of this specimen resemble remarkably closely those of the Lower Pennsylvanian forms of America which are generally referred to *Staffella*, but its spirotheca is thicker and apparently is composed of only two layers. In many respects this form resembles the type of the genus *Sphaerulina* Lee, *S. crassispira* Lee, and it may be referable to that genus. However, the periphery of its juvenarium is not as nearly subangular as the juvenarium of the type of that genus and its general shape seems to be different.

Occurrence.—This form occurs in a light-gray dense limestone, about 1⅛ miles east of Shin K'ai Shi near the Foster Bungalow, where it is associated with *Sumatrina annae* Volz ?, *Schubertella simplex* Lange, *Schwagerina* sp., and *Verbeekina heimi*, n. sp.

Subfamily SCHWAGERININAE Dunbar and Henbest

Genus SCHWAGERINA Möller, 1877

SCHWAGERINA sp.
Plate 25, figure 1

Only a few specimens of this form have been found among our collections and they are not well enough oriented for specific identification. However, these sections show the general characters which identify them as representing the genus *Schwagerina*, as recently redefined by Dunbar and Skinner (1936). For the sake of completeness we are illustrating one of these specimens.

Occurrence.—This form occurs in a light-gray dense limestone, about 1⅛ miles east of Shin K'ai Shi, where it is associated with *Sumatrina annae* Volz?, *Staffella* ? sp., *Schubertella simplex* Lange, and *Verbeekina heimi*, n. sp.

Subfamily VERBEEKININAE Staff and Wedekind

Genus EOVERBEEKINA Lee, 1933

The genus *Eoverbeekina* was established by Lee (1933) with *E. intermedia* Lee as genotype. Lee compared *E. intermedia* with *Staffella moellerana* Thompson [= *Fusulinella sphaerica* Möller] from Armenia and there are several points which strongly suggest that they are congeneric. They are about the same in size and shape. *S. moellerana* is the type of the genus *Staffella* Ozawa but Möller's illustrated axial section does not show well developed chomata and it is several times larger than the Lower Pennsylvanian forms which are generally referred to *Staffella*. *S. moellerana* contains more volutions than the Lower Pennsylvanian forms generally referred to *Staffella* and it seems probable that they are not congeneric. The precise age of the genotype of *Staffella* is somewhat uncertain but it may be of about the same age as *E. intermedia* and they may be congeneric; in which case *Eoverbeekina* is a synonym of *Staffella*, which has priority. This cannot be determined, however, until the syntypes or good topotypes of *S. moellerana* are studied in the light of our present knowledge of the fusulinids.

Eoverbeekina is very closely similar in shape and general development to *Verbeekina* Staff and, as suggested by Lee, it is probably ancestral to *Verbeekina*. Representatives of these two genera may be distinguished rather easily, for in *Eoverbeekina* the juvenarium is lenticular and its periphery is angular, the shell possesses a tunnel which is not found in *Verbeekina*, and the parachomata are not developed as in *Verbeekina*.

EOVERBEEKINA CHENI Thompson and Foster, n. sp.

Plate 23, figure 12; Plate 24, figure 11

Eoverbeekina (?) or *Sphaerulina* (?) LEE, *1933*, Nat. Research Inst. Geology, Mem., no. 14, p. 24, pl. 1, fig. 5.

Eoverbeekina intermedia CHEN, *1934*, Palaeontologia Sinica, ser. B. vol. 4, fasc. 2, pp. 103–105, pl. 2, fig. 11.

Shell of medium size, essentially spherical. Our largest specimens are composed of nine volutions and they measure about 3.7 mm. in length and 3.7 mm. in width. The form ratio is 1:0.5 for the second volution, 1:1 for the fourth volution, 1:1.2 for the fifth volution, and 1:1 for the ninth volution. The periphery of the inner three volutions is subangular, but beyond the third volution the periphery becomes broadly rounded.

The septa are thin and they are composed of a tectum and a rather thin layer of lighter material on the posterior side. The septa are rather closely spaced, and they are unfluted throughout the shell.

The spirotheca is composed of a tectum and a finely alveoli keriotheca. Its thickness for the fifth to the ninth volution measures about 17, 26, 43, 60, and 80μ.

The proloculum is very small and its inside diameter measures about 25μ. The juvenarium is composed of three to three and one-half volutions and it is very tightly coiled. Beyond the juvenarium the shell expands rather rapidly. The heights (in microns) of the first to the eighth volutions measure about 43, 60, 70, 130, 215, 320, 390, and 320.

Foramina are abundant in the outer five volutions of forms of nine volutions, and they are more or less circular in cross section. We have not been able to recognize foramina in the inner four volutions. A small triangular tunnel is present in the subangular periphery of the juvenarium, and in the outer volutions the tunnel is very low and rather narrow. We have not recognized chomata or parachomata in this form.

All of the specimens in our collection may be immature, but in the outer portion of forms of nine volutions the coiling becomes tighter, and hence these forms are probably mature or sub-mature.

Remarks—The type of genus *Eoverbeekina*, *E. intermedia* Lee, is the only

other described representative of this genus. It can be distinguished easily from the form described above by its larger form ratio, more tightly coiled shell, larger number of volutions, and apparently better developed tunnel. *E. cheni* resembles very closely the axial section of the form from the Chihsia limestone of southeastern China illustrated by Lee as "*Eoverbeekina*(?) or *Sphaerulina*(?)" and later described and illustrated by Chen as *Eoverbeekina intermedia* Lee, and these two forms are probably conspecific.

Occurrence.—This species occurs rather abundantly in a dark-gray to black, slightly cherty limestone near the Wellwood Bungalow, about one-fourth of a mile due east of the peak of Shin K'ai Shi, where it is associated with *Neofusulinella lantenoisi* Deprat and *Ozawainella* sp. Lee and Chen illustrated specimens from the Chihsia limestone of southeastern China which we are referring to this species.

Genus VERBEEKINA Staff, 1909

The genus *Verbeekina* was established by Staff (1909) as a subgenus of *Doliolina* Schellwien, but it has since been raised to the rank of a separate genus. Thompson (1936) has recently discussed this genus at some length in this Journal, as based on topotype material of the genotype from Bukit Bessi, Sumatra, and we do not have any additional general information to add to this discussion.

VERBEEKINA GRABAUI Thompson and Foster, n. sp.

Plate 23, figures 14–16

Shell essentially spherical, slightly umbilicate. Mature forms consist of thirteen to fourteen volutions and specimens of thirteen volutions measure about 4.8 mm. in length and 4.8 mm. in width. The form ratio is about 1:0.66 for the second volution, 1:0.88 for the fourth volution, and 1:1 for the sixth to the fourteenth volutions. The widths (in millimeters) of the first to the fourteenth volutions are about 0.127, 0.211, 0.295, 0.435, 0.749, 1.169, 1.679, 2.129, 2.579, 3.029, 3.479, 3.929, 4.349, and 4.751.

The proloculum is very small and its inside diameter measures about 35μ. The shell expands very slowly for the first three volutions, it then expands rapidly and reaches a maximum in the sixth to the tenth volutions, and in the outer two to three volutions of mature individuals it becomes rather tightly coiled. The heights (in microns) of the first thirteen volutions are about 42, 42, 70, 157, 210, 255, 225, 225, 225, 255, 225, 210, and 196. The juvenarium is endothyroid, it has a large form ratio, and its axis of coiling is parallel to that of the outer volutions.

The spirotheca is thin. It is composed of a tectum, a keriotheca, and a thin dense lower layer. The upper surface of the spirotheca is coated by dense calcite which apparently is extension of the parachomata. The keriotheca contains numerous dark lines which are normal to its surfaces and which apparently correspond to the dark lines of the alveoli of other fusulinids. The spirotheca (tectum plus the keriotheca) increases in thickness from a very thin layer in the first volution to 5μ in the third volution; it then apparently decreases in thickness to about 2μ in the fourth, fifth, and sixth volutions; and it gradually increases in thickness for the remaining outer volutions. The thickness (in microns) of the spirotheca for the seventh to the thirteenth volutions measures about 5, 6, 7, 8, 10, 10, and 10.

The septa are thin and rather numerous. The septal count for the sixth to the twelfth volutions gives 11, 12, 15, 20, 33, 37, and 36. The septa extend forward so as to join the spirotheca of the preceding volution at an angle of about 15 degrees from normal.

The foramina are small and essentially circular in cross section. They are well developed throughout the shell. There are about 8 foramina in the fourth volution and 38 in the twelfth volution. The parachomata are essentially undeveloped

in the inner volutions and they extend completely across the chambers only in the outer two to three volutions of mature specimens.

Remarks.—This is one of the smallest species of *Verbeekina* so far described. It compares favorably in size and rate of expansion for the first eight volutions with the types of *V. sphaera* Ozawa from Nagato. However, only one incomplete sagittal section of a young individual was illustrated from Nagato by Ozawa. Later Ozawa (1927) illustrated, but did not describe in detail, numerous specimens from Akasaka as *Verbeekina verbeeki sphaera*. Ozawa was regarding the variety *V. verbeeki verbeeki* as a mutation of the variety *sphaera* and he illustrated a large and a small type under the varietal name *sphaera*. A part of the illustrated small type of specimens (Ozawa's fig. 15 on his pl. 38) may possibly be conspecific with our specimens, but others of his small type from Akasaka have much better developed parachomata than *V. grabaui*. The spirotheca of *V. sphaera* from Nagato is thicker than that of *V. grabaui*, and from Ozawa's comparison of his form with other described forms, it probably is much larger at maturity than *V. grabaui*.

Chen's brief description of *V. minor* Chen of the Chihsia limestone of southeastern China agrees closely with our specimens, but Chen's description is based mainly on a section which is tangential to the fourth or fifth volution. His illustrated section apparently is of a specimen of about twelve volutions which measures about 2.4 mm. in width. This form then is only about one-half as large as our specimens of an equal number of volutions. Chen's illustration and description are not adequate for specific comparisons. *V. minor* probably is the smallest known representative of *Verbeekina*.

Occurrence.—Shells of this form are rather abundant in a gray, slightly cherty dense limestone, about 5,000 feet east of Shin K'ai Shi and 500 feet east of the Davies Bungalow, where it is associated with *Neoschwagerina* aff. *N. charticulifera* (Schwager), *Pseudodoliolina pseudolepida* (Deprat), and *Schubertella simplex* Lange.

VERBEEKINA HEIMI Thompson and Foster, n. sp.

Plate 23, figures 1–3; Plate 24, figure 5; Plate 25, figures 5, 6

(?) *Schwagerina verbeeki* COLANI, *1924*, Indochine Service géol., Mém., vol. 11, fasc. 1, pp. 108–113, 147–149, pl. 15, fig. 14, pl. 18, figs. 2, 5, 16–21, pl. 19, figs. 1–9, 11, 13.

Shell large, essentially spherical. Mature specimens consist of fifteen to sixteen volutions, and they are about 8 mm. in length and 8 mm. in width. The form ratio is about 1 : 0.36 for the second volution, 1 : 0.87 for the fifth volution, and 1 : 1 for the eighth and remaining outer volutions. The average widths (in millimeters) of the first to the sixteenth volutions of six typical specimens measure 0.062, 0.126, 0.220, 0.376, 0.608, 0.988, 1.538, 2.214, 2.978, 3.920, 4.720, 5.484, 6.138, 6.778, 7.344, and 7.884.

The proloculum is very small and its inside diameter measures 20 to 30μ. The juvenarium is composed of four to five volutions, its axis of coiling is parallel to that of the outer volutions, and it has a large form ratio. The average heights (in microns) of the first to the sixteenth volution of six typical specimens are 21, 32, 47, 78, 116, 190, 275, 338, 382, 425, 400, 382, 327, 320, 283, and 270.

The septa are thin. They are very numerous in the outer volutions of mature specimens but they are widely spaced in the inner volutions. The septal count for the fourth to the fifteenth volutions gives 9, 6, 8, 11, 9, 10, 16, 27, 37, 48, 50, and 56.

The spirotheca is thin and its structure is typical of the genus. It increases in thickness rather gradually throughout the shell. The average thickness (in microns) of the spirotheca for the fourth to the sixteenth volution of six typical specimens is 7.8, 8.7, 9.5, 11.3, 12.2, 19.2, 26.2, 36.7, 38.6, 39, 37.5, 36, and 36.

The foramina are very low and typi-

cally they are very elongate elliptical in cross section, but some of them are short and circular in cross section. There are about 8 foramina in the fifth volution, 39 in the eleventh volution, and 55 in the fourteenth volution. The parachomata are very poorly developed in this species and they apparently do not extend completely across the chambers except in the fifteenth and sixteenth volutions.

Remarks.—This species is somewhat closely similar to *Verbeekina verbeeki* (Geinitz). The general shapes of the shells of these two forms are very similar, but the spirotheca of our specimens is much thinner than that of *V. verbeeki*, the parachomata are not as well developed, and the expansion of the shell is more rapid in *V. heimi*. *V. heimi* is smaller for corresponding volutions and it is smaller at maturity than *V. pseudoverbeeki* (Deprat) and *V. douvillei* (Deprat). *V. deprati* (Yabe) is very closely similar to *V. heimi* but that species expands more slowly than the form we are studying and Deprat's illustrations and description of that species indicate that its spirotheca is much thicker than that of the species we are studying. *V. heimi* has a shorter shell, slightly more rapidly expanding shell, fewer septa, and more poorly developed parachomata than *V. akasakensis* Thompson. *V. heimi* is very distinct from the form described above as *V. grabaui*, n. sp.

Occurrence.—This form occurs very abundantly in a light-gray dense limestone near the Foster Bungalow about 1⅛ miles east of Shin K'ai Shi, where it is associated with *Sumatrina annae* Volz ?, *Staffella* ? sp., *Schubertella simplex* Lange, and *Schwagerina* sp.; and in a light-gray, dense limestone, in the cliff below the Davies Bungalow about 5,000 feet east of Shin K'ai Shi.

Genus PSEUDODOLIOLINA Yabe and Hanzawa, 1932

Schellwien (1898) established the genus *Möllerina* with *Schwagerina lepida* Schwager as genotype. This generic name was preoccupied and Schellwien (1902) proposed the name *Doliolina* for that genus. Deprat (1914) and Ozawa (1927) described and illustrated forms from Akasaka, Japan, as *D. lepida* which appear to have spirotheca composed of only one compact layer. The proloculum of these forms is rather large, the innermost volutions are roughly fusiform, and the shell of mature individuals is very elongate ellipsoidal. In 1929 Ozawa [see Dunbar and Henbest (1930) and Yabe and Hanzawa (1932)] examined Schwager's types of *D. lepida* and found that their spirotheca in reality possesses a distinct keriotheca, as originally described and illustrated by Schwager. Primarily on the basis of this study by Ozawa, Yabe and Hanzawa (1932) established *Pseudodoliolina* and they referred to Deprat's and a part of Ozawa's illustrated specimens from Akasaka as the genotype. They considered Deprat's and Ozawa's specimens conspecific and coined the name *Pseudodoliolina ozawai* for them.

In proposing the name *Pseudodoliolina ozawai*, Yabe and Hanzawa referred to Deprat's figures 12–14 on his plate 3, which Deprat labeled as *Doliolina lepida* Schwager, and to Ozawa's figures 1 and 2 on his plate 45 which Ozawa labeled *Doliolina lepida* mut. *pseudolepida* Deprat and *Doliolina lepida magnae* Deprat, respectively. We are not certain to which of Deprat's forms Ozawa had reference, for, so far as we know, Deprat never used the term *magnae* as a specific or varietal name with *Doliolina*. It seems clear to us that Ozawa's two illustrated sections are not conspecific with Deprat's illustrated form, and hence we are regarding Deprat's illustrated specimens as being typical of *P. ozawai* Yabe and Hanzawa and are designating the specimen illustrated by Deprat as figure 12 on his plate 3 as the holotype of that species. In his discussion of the fusulinids of Akasaka, Ozawa (1927) pointed out that the group of forms he was referring to

D. lepida became larger in the upper horizons of the Akasaka limestone and his large form figured as *Doliolina lepida* mut. *pseudolepida* undoubtedly came from this upper horizon. We are referring this specimen of Ozawa's with question to *P. pseudolepida*. Ozawa's *D. lepida magnae* may not be referable to the genus *Pseudodoliolina*. Deprat's illustrated sections are small and are apparently from the lower horizons of the Akasaka limestones, sometimes referred to as the Nezumi zone, as named from the quarry by that name, which has long been a famous collecting locality near Akasaka. It seems entirely possible that Deprat's illustrated specimens were collected from the well-known Nezumi quarry.

Through the kindness of Prof. H. Yabe we have had the opportunity to examine some type material of this genotype from the Nezumi zone at Akasaka (see pl. 24, figs. 9, 10) and our West China specimens described below as *Pseudodoliolina pseudolepida* clearly are congeneric with this genotype. A very careful study of many thin sections of this type material of *P. ozawai* reveals that in the inner volutions only one thin compact layer can be recognized but, in contrast to the observations of several paleontologists that the spirotheca is composed of only a tectum, beyond the tenth volution the spirotheca clearly is composed of three layers—a tectum, a thin inner layer, and a lighter central layer which apparently corresponds to the keriotheca of other fusulinids and which contains very fine more or less parallel dark lines normal to its surfaces. This fine mesh-work apparently is homologous to the alveoli of the genus *Verbeekina*.

Gubler (1935) has recently restudied Schwager's syntypes of *D. lepida* and has re-illustrated (with excellent photographs) a part of Schwager's sections. Gubler's study shows that the spirotheca of this genotype is very thin. In the inner volutions it appears to be composed of one layer but in the outer volutions it clearly is composed of a tectum, a keriotheca, and a thin inner layer. Since *Pseudodoliolina* and *Doliolina* were first distinguished by the supposed difference in the structure of their spirotheca, it would now seem that they are exact synonyms. However, there are other marked differences between the types of these two genera which should be considered. The proloculum of *P. ozawai* is rather large and the juvenarium is essentially fusiform. The proloculum of *D. lepida* is very small and the juvenarium is distinctly endothyroid. Some students contend that these two species are synonymous and that the two types just mentioned are dimorphic representatives of the same species. A study of others of the higher genera of fusulinids gives us a little better idea of the generic characters of these two general types. The juvenarium of *Verbeekina* is very similar to that of the type specimens of *D. lepida*. We have studied numerous sections of representatives of *Verbeekina* from many parts of Asia, also many well centered sections of this same genus have been illustrated, and in every case the proloculum is minute and the juvenarium is decidedly endothyroid. With several other highly developed genera of the fusulinids the proloculum is invariably large. We have sectioned hundreds of specimens of the type material of *P. ozawai* and many of them pass through the proloculum and about fifteen of these are well oriented, and in every case the proloculum is large and the inner volutions are essentially fusiform. These several facts lead us to believe that *Pseudodoliolina* should be recognized, for the present at least, as a valid genus.

Diagnosis of Pseudodoliolina.—Shell of medium size, elongate ellipsoidal. Axis of coiling essentially straight. Poles very blunt and broadly rounded—hemispherical. Mature forms consist of fourteen to twenty volutions, and they are 5 to 8 mm. in length and 2.5 to 4 mm. in width. The form ratio varies with different forms and it is 1:1.6 to 1:2.6. The inside diameter of the proloculum measures 100

to 300μ. Typically the inner two to three volutions are fusiform and beyond the third volution the poles become dome-shaped and the central portion of the shell becomes subcylindrical. Septa very numerous. They are composed of the downward deflection of the spirotheca and they are coated on both sides with rather dense calcite which apparently is a continuation of the parachomata. The septa are unfluted throughout all stages. The basal portion of the septa is perforated by numerous elliptical foramina. In all volutions, either side of the foramina is bordered by rather narrow parachomata which are continuous from one septa to the next and which may reach to the top of the chambers just anterior of the septa. The spirotheca is very thin and in the inner ten volutions it appears to be composed of only one thin, rather compact layer. However, in the twelfth volution of some very thin sections of well preserved specimens of type material of the genotype, the spirotheca clearly is composed of a tectum, a thin inner layer, and a thin keriotheca with very fine parallel dark lines normal to its surfaces that probably correspond to the alveoli of other genera of fusulinids. The spirotheca of the twelfth volution of one of these specimens measures about 12μ.

Remarks.—The forms of the group which we are referring to *Pseudodoliolina* differ from representatives of *Doliolina* in that their spirotheca is typically thinner, their parachomata are higher and narrower, and their juvenarium is quite different. In *Doliolina* the proloculum is very small and the innermost volutions are staffelloid but in *Pseudodoliolina* the proloculum is large and the innermost volutions are elongate and more or less fusiform.

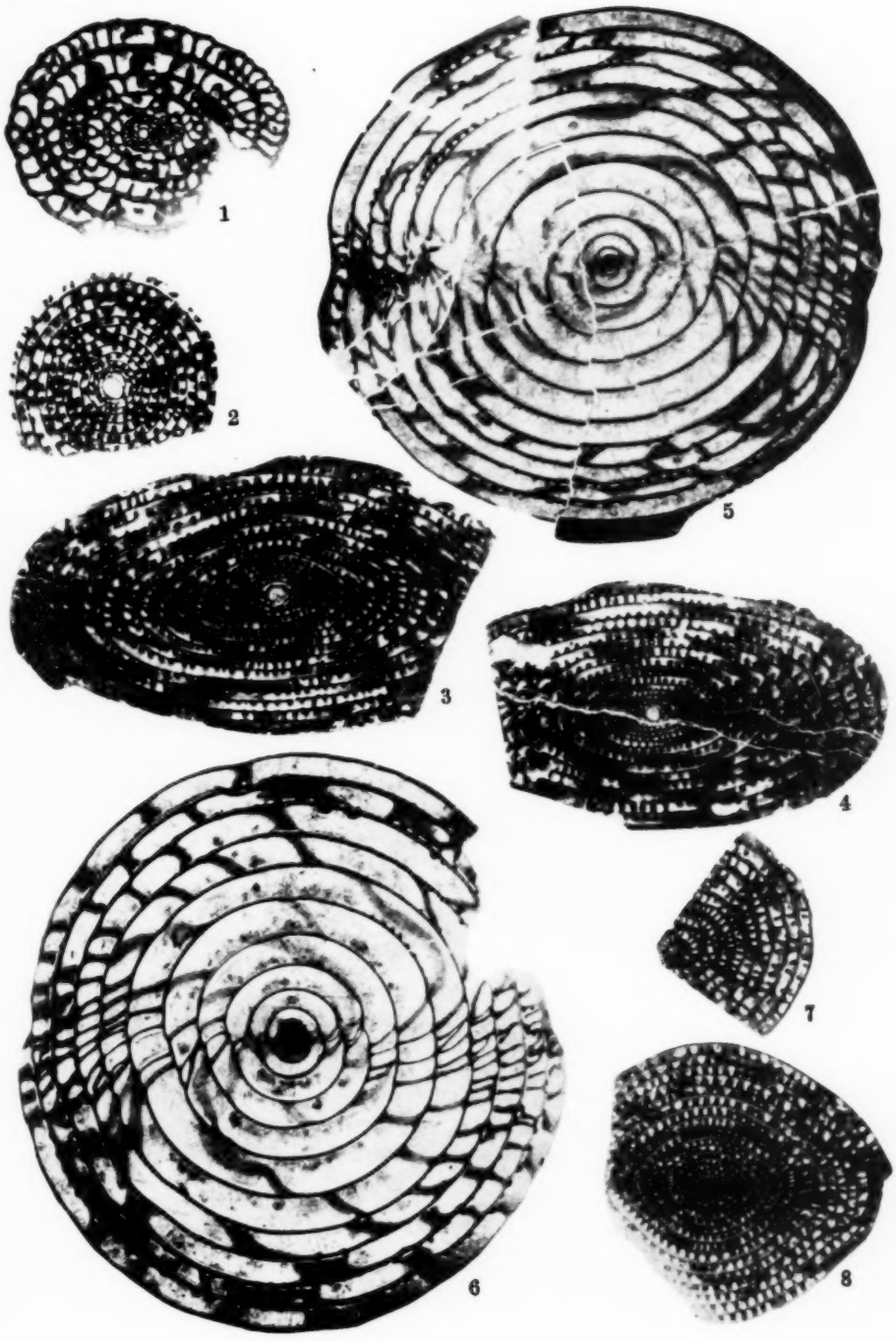
The genus *Doliolina*, as here defined, includes a rather wide variety of forms with *D. claudiae* and *D. compressa* on the one hand and *D. lepida* and *D. major* (?=*D. lepida*) on the other. In *D. claudiae* the spirotheca is very thick, the shell is small and short, and the parachomata are rather low and broad. In *D. lepida* the spirotheca is relatively thin, the shell is large and elongate, and the parachomata are narrower and higher. Unfortunately, *D. lepida* does not occupy an intermediate position for the genus. In addition to the four forms just mentioned, the following forms seem to be referable to *Doliolina: D. aliciae* Deprat, *D. ovalis* Deprat, *D. subelliptica* Deprat, *D. parvicostata* Deprat, *D. termieri* Deprat, *D. minor* Deprat, *D. minima* Lange, *D. termieri* var. *pamirensis* Doutkevitch.

The following forms seem to us to be congeneric with *Pseudodoliolina ozawai* and we are referring them to *Pseudodoliolina: Doliolina pseudolepida* Deprat, 1912, *D. lepida* Deprat, 1912, *D. lepida* var. *lettensis* Schubert, 1915, *D. lepida* Lange, 1925, and *D. dunbari* Gubler, 1935. With many of these forms, such as *Pseudodoliolina lettensis* (Schubert) and *P. pseudolepida* (Deprat), the parachomata reach entirely to the top of the chambers immediately anterior of the septa and give the appearance of transverse septula. *Doliolina schellwieni* Deprat resembles in many respects these forms but it apparently possesses longitudinal septula in its outer volutions and it may be referable to *Neoschwagerina* Yabe.

EXPLANATION OF PLATE 25

All illustrations on this plate are unretouched photographs and are magnified ×10. All of the specimens are from the upper portion of the Yanghsin limestone on Shin K'ai Shi, Szechuan, China.

FIGS. *1*—*Schwagerina* sp. Oblique sagittal section. (p. 134)
2–4—*Pseudodoliolina pseudolepida* (Deprat). *2*, Sagittal section. *3*, *4*, Axial sections. (p. 141)
5, *6*—*Verbeekina heimi* Thompson and Foster, n. sp. Axial sections. (p. 137)
7, *8*—*Neoschwagerina* aff. *N. craticulifera* (Schwager). *7*, Portion of a parallel section. *8*, Axial section. (p. 142)



Thompson and Foster, Permian Fusulinids

UNIV. OF MICH.

PSEUDODOLIOLINA PSEUDOLEPIDA
(Deprat)

Plate 25, figures 2–4

Doliolina pseudolepida DEPRAT, *1912*, Indochine Service géol, Mém., vol. 1, fasc. 3, p. 46, pl. 5, figs. 6–9, pl. 6, fig. 4.
Doliolina lepida mut. *pseudolepida* DEPRAT, *1913*, Indochine Service géol., Mém., vol. 2, fasc. 1, p. 50.
(?) *Doliolina lepida* OZAWA, *1927*, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2 (Geology), vol. 2, pt. 3, pp. 152, 153, pl. 45, fig. 1.

Shell large, ellipsoidal, slightly inflated in the central portion. External furrows shallow and faint. Axis of coiling essentially straight. Poles very broadly rounded (hemispherical). Lateral slopes low and convex. The innermost volution has pointed poles and it is broadly fusiform; the third and fourth volutions become elongate ellipsoidal; and the central portion of the shell becomes slightly inflated in the outermost volutions of mature individuals. Mature specimens consisted of at least eighteen volutions and they measure about 7.5 mm. in length and 4 mm. in width. The form ratio is about 1:1.6 for the first volution, 1:2 for the fifth volution, 1:1.9 for the tenth volution, and 1:1.8 for the eighteenth volution.

The septa are thin and they are coated on either side with deposits of dense calcite which apparently are continuations of the parachomata. The septal count of the first seven volutions is 11, 20, 20, 20, 21, 28, and 33. The septa are unfluted throughout the length of the shell.

The spirotheca is very thin in the inner volutions and it appears to be composed of one layer. In the outer volutions the spirotheca is composed of a tectum, a thin clear central layer, and a lower very thin dense layer. The upper surface of the spirotheca is coated with a more or less continuous layer of dense calcite which seems to be continuous with the parachomata.

The proloculum is large and is ellipsoidal to spherical in shape. Its inside diameter measures 200 to 300μ. The rate of expansion of the shell is rather uniform and the heights (in microns) of the first fifteen volutions measure about 40, 40, 55, 70, 80, 100, 120, 120, 120, 140, 140, 140, 155, 155, and 140.

The basal portion of the septa is perforated by numerous small elliptical foramina. There are about 20 foramina in the fifth volution, 35 in the tenth volution, and 50 in the fourteenth volution. Parachomata are well developed in the intervening spaces between the foramina throughout the shell. The parachomata extend completely to the top of the chambers just anterior of the septa and the lateral communication is a small circular opening near the top and front of the chambers. The parachomata resemble septula in some portions of axial sections.

Remarks.—The specimens from the Mt. Omei region on which the above description is based are apparently conspecific with Deprat's syntypes from Yunnan and they differ from them only in that their proloculum is slightly larger, they contain more volutions, and they have a few more foramina in corresponding outer volutions. Ozawa did not describe his form from Akasaka and it is doubtful to us if it is referable to this species.

Pseudodoliolina pseudolepida has been placed in synonymy with *P. ozawai* (= *Doliolina lepida* of authors) by several paleontologists. However, a direct comparison of the two forms brings out several distinct differences. The shapes of the shells of these two species are quite different and *P. ozawai* is smaller and has a smaller proloculum.

The relationship between *P. pseudolepida* and the form described by Deprat in 1912 as *Doliolina lepida* from the Permian of Yunnan is not clear to us. In 1912 Deprat pointed out that *P. pseudolepida* expands more slowly, has thinner spirotheca, and has a larger proloculum than his *D. lepida*. However, in 1913 Deprat considered *P. pseudolepida* merely as a mutation of the form which he described and illustrated as *D. lepida*, but we now know that in 1913 Deprat was

referring several species of two genera to *Doliolina lepida*. Deprat's illustrated *D. lepida* of 1912 is referable to *Pseudodoliolina*, and it may be conspecific with *P. pseudolepida*.

Occurrence.—Deprat's original types came from Tou-La-Houe, Yunnan, where, according to Deprat, they are associated with "*N.* (*Sumatrina*) *annae* Volz, *Schwag. douvillei* n. sp., *Fusulina exilis* Schwag., *F. margheritii*." In 1913 Deprat reported this form from Pongoua, Laos, in the same horizon with "*Fusulina*" *gigantea* Deprat and "*Fusulina*" *crassa* Deprat. Ozawa illustrated a form from the Permian limestone (presumably from the upper part of the limestone) of Akasaka, Japan, which may be referable to this species. The specimens described above came from a medium-gray, slightly cherty limestone, about 5,000 feet east of Shin K'ai Shi and 500 feet east of the Davies Bungalow, where it is associated with *Neoschwagerina* aff. *N. craticulifera* (Schwager), *Schubertella simplex* Lange, and *Verbeekina grabaui*, n. sp.

Subfamily NEOSCHWAGERININAE Dunbar and Condra

Genus NEOSCHWAGERINA Yabe, 1903

NEOSCHWAGERINA sp. aff. N. CRATICULIFERA (Schwager)

Plate 25, figures 7, 8

We have only two specimens of this form among our collections. Neither of these specimens is well-centered and neither of them is complete. However, the preservation of the internal structures is very good and most of the specific characters can be determined. Several of the observable characters of the specimens before us differ from those of the description and illustrations of the syntypes of *N. craticulifera*, but since a specific description based on our specimens would be incomplete, we hesitate to make them the types of a new species. The following brief description is based entirely on our specimens.

Shell of medium size, short, obese. Poles narrowly rounded. Lateral slopes rather steep and convex. Our axial section of nineteen volutions measures 4.8 mm. in length and 3.7 mm. in width. The form ratio is about 1:1.1 for the third volution and it is about 1:1.3 for the fifth to the nineteenth volution. The spirotheca is thin and it is composed of a tectum and a keriotheca with fine alveoli. The keriotheca extends downward at rather regular intervals to form pendant-like longitudinal as well as transverse septula and the alveoli continue almost to the base of the septula. In the fifteenth to the nineteenth volutions there are low longitudinal septula between each pair of primary septa. Transverse septula extend down in the space between each pair of foramina and they are connected with the parachomata almost completely across the chambers.

The septa are rather thick and they are composed of the tectum and extensions of the keriotheca of the spirotheca down both sides of the tectum. The septa are rather widely spaced and there are about 28 in the fifteenth volution.

The proloculum is very minute and it measures about 30μ in diameter. The inner volutions are very tightly coiled and the increase in the height of the chambers is very gradual. The foramina are small and they are circular in cross section. There are about 10 foramina in the fifth volution, 20 in the tenth volution, 30 in the fifteenth volution, and 38 in the nineteenth volution. The parachomata are rather well developed throughout the shell.

Remarks.—The specimens described above apparently are slightly more obese than the types of *N. craticulifera* but our axial section is slightly oblique. Also, our largest specimen contains more volutions and is slightly larger than the measurements given for the types of that species. However, these two forms are undoubtedly very closely related.

Occurrence.—Our specimens of this

form came from a medium-gray, slightly cherty limestone, about 1 mile east of Shin K'ai Shi and 500 feet east of the Davies Bungalow, where it is associated with *Pseudodoliolina pseudolepida* (Deprat), *Schubertella simplex* Lange, and *Verbeekina grabaui*, n. sp.

Genus SUMATRINA Volz, 1904

SUMATRINA ANNAE Volz ?
Plate 23, figure 13

Sumatrina annae VOLZ, *1904*, Geol. palaeont., Abh., N. F., Band 6 (der ganzen Reihe Bd. 10), Heft 2, pp. 98–100, text-figs. 27–31.—DOUVILLÉ, *1906*, Soc. géol. France, Bull., sér. 4, tome 6, pp. 582, 583, text-figs. 7–10.—(?) OZAWA, *1925*, Tokyo Imp. Univ., Coll. Sci., Jour., vol. 45, art. 4, pl. 1, fig. 10a; *1925*, Tokyo Imp. Univ., Coll. Sci., Jour., vol. 45, art. 6, p. 64, pl. 1, figs. 1*b*, 2*b*; pl. 10, fig. 8; *1927*, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2 (Geology), vol. 2, pt. 3, p. 161.— ? CHAPUT, *1932*, Acad. sci. Paris, Comptes rendus, tome 194, pp. 1592, 1593.

Neoschwagerina annae ? YABE, *1906*, Tokyo Imp. Univ., Coll. Sci., Jour., vol. 21, art. 5, pl. 2, fig. 4.— ? HAYDEN, *1909*, India Geol. Survey, Records, vol. 38, pp. 250, 251, pl. 22, figs. 8–14.

Neoschwagerina (*Sumatrina*) *annae* DEPRAT, *1912*, Indochine Service géol., Mém., vol. 1, fasc. 3, pp. 56, 57, pl. 5, figs. 1, 3–5.

We have discovered only one section of the genus *Sumatrina* among our collections from western China. This is a slightly tangential section of an incompletely preserved specimen of about six volutions. Although the preservation of this specimen is such that a specific determination cannot be made with certainty, the presence of this highly specialized genus in the Mt. Omei region is of considerable stratigraphic significance. *Sumatrina* is very widespread in southern Europe and southern Asia and it is almost invariably associated with Middle and Upper Permian fusulinid genera such as those found in the same specimen of limestone with our specimen of *Sumatrina* from near Mt. Omei. So far as known, *Sumatrina* does not occur in strata older than Middle Permian, as the Permian is generally defined.

Our specimen is not well enough preserved to determine its specific affinities with certainty, but it resembles in many respects the types of *S. annae* from Sumatra and we are referring it to that species with question. The following brief description is based entirely on our figured specimen.

Shell small, elongate fusiform. Poles rather sharply pointed. Axis of coiling straight. Specimen of six volutions measures 5 mm. in length and about 1.5 mm. in width. The form ratio is about 1:3.3. The development of the primary and secondary septula is typical of the genus and in the sixth volution there are four secondary transverse septula for each primary transverse septula. Heavy deposits of dense calcite tend to fill the axial region and extend out on the upper side of the spirotheca toward the center of the shell.

Remarks.—Many of the references listed in the above synonymy probably do not deal with specimens conspecific with Volz's type specimens from Sumatra, but since in many cases the illustrations and descriptions do not permit detailed specific comparisons, we are tentatively leaving them as originally referred to this species. Most of the forms referred to this species by Ozawa from Japan and the form referred to it by Hayden from Afghanistan seem to us to be shorter and more highly inflated than Volz's types. Also, Chaput did not describe or illustrate his specimens from Asia Minor.

Occurrence.—The syntypes of this species came from Bukit Bessi, Sumatra, where they were associated with *Verbeekina verbeeki* (Geinitz) and *Parafusulina ? granum-avenae* (Roemer). Ozawa and Yabe have described specimens from Japan which may be conspecific. Hayden referred a form to this species from Afghanistan, and Chaput referred a form to it from Asia Minor where it is associated with "*Verbeekina verbeeki*." Our specimen came from a light-gray, dense limestone, about 1⅛ miles east of Shin K'ai Shi near the Foster Bungalow, where it is associated with *Staffella ?*

sp., *Schubertella simplex* Lange, *Schwagerina* sp., and *Verbeekina heimi*, n. sp.

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C. L. FOSTER, BACONE COLLEGE, BACONE, OKLAHOMA. MANUSCRIPT RECEIVED BY THE EDITOR, JULY 1, 1936.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO 2, PP. 145–159, PL. 26, 27 TEXT-FIGS., MARCH, 1937

MIDDLE TERTIARY OSTRACODA OF THE GENUS *CYTHERIDEA*

MORTON B. STEPHENSON

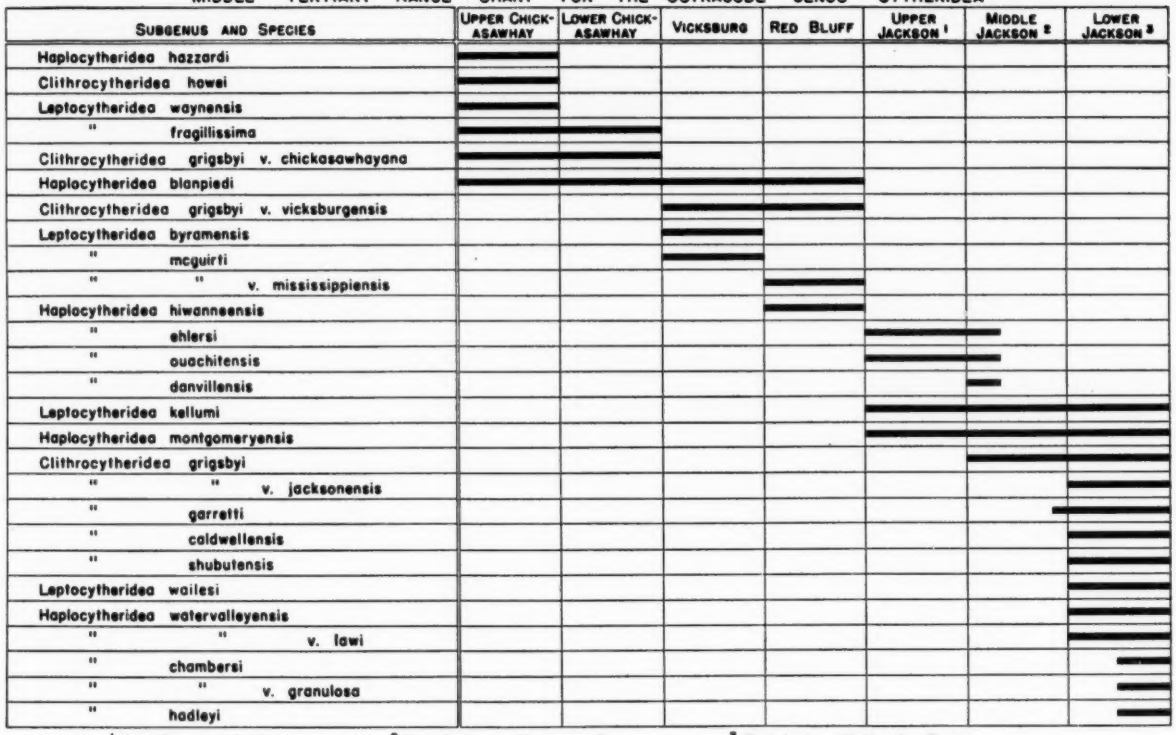
ABSTRACT

The shell structure of the ostracode genus *Cytheridea* is described. Twelve new species and five new varieties belonging to this genus are also described. A new subgenus, *Leptocytheridea*, is erected to receive several of the species. These microfossils come from beds of the Jackson (Eocene), Red Bluff (Oligocene), and the lower and upper Chickasawhay members of the Catahoula (Miocene) of the Gulf Coast.

Published works on the Ostracoda of Middle Tertiary beds of the Gulf Coast have appeared at intervals during the past two years, adding several excellent detailed reports to the literature. These include a study of the microfaunal assemblage of the Chickasawhay (Miocene) by Howe (1934, pp. 24, 25, pl. 1, and ostracode correlation chart) in which six species of *Cytheridea* were listed but not described, and their ranges noted; a bulletin on the Ostracoda of the Jackson (Eocene) of Louisiana by Howe and Chambers (1935), containing descriptions of six species of *Cytheridea;* and a contribution by Howe and Law (1936) on ostracodes of the Vicksburg group of Louisiana, in which I described four species of *Cytheridea*.

The paper here presented contains descriptions of species of *Cytheridea*, ranging in age through the Jackson group (Eocene), the Red Bluff (Oligocene), and the lower and upper Chickasawhay members of the Catahoula formation (Miocene). A number of species, heretofore undescribed in the Louisiana bulletins because of their absence in samples from that state, are here included from Jackson localities in Mississippi. The material from Loc. 1, on Town Creek near Jackson, Miss., proved very fossiliferous, and yielded several new Jackson species. This sample represents beds of the basal Moody's Branch marl, or an immediately underlying horizon near the contact with the Claiborne, and it carries several species observed elsewhere by me only in material from the transition zone below the Moody's Branch marl on Garland Creek, Clarke County, Miss. A single station in the Red Bluff, at Hiwannee, Miss., was chosen from a number of samples because of its larger faunal content. Specimens of *Cytheridea* are very rare in the Red Bluff, and represent only a very few species, including occasional specimens of reworked material from the underlying Jackson. The genus *Eucythere* is much more common, and it seems probable that here, as Howe (1936, p. 143) has observed in the Byram marl (Oligocene), this genus has largely replaced *Cytheridea*. The faunal break at the top of the Vicksburg is pronounced, with only one of the Oligocene species ranging

MIDDLE TERTIARY RANGE CHART FOR THE OSTRACODE GENUS CYTHERIDEA



[1] Massilina pratti Zone [2] Textularia hockleyensis Zone [3] Textularia dibollensis Zone

into the Chickasawhay. The upper Chickasawhay carries a larger representation of *Cytheridea* than the lower member, three species being restricted to the upper Chickasawhay.

A detailed study of the Tertiary species here presented has revealed the existence of a group within the genus *Cytheridea* which is distinct from the genotype, *C. mülleri* (Münster), of the European subgenus *Cytheridea*. The group is likewise readily separable from the two subgenera *Haplocytheridea* and *Clithrocytheridea*, previously established by me to include a number of species in the American Tertiary. Therefore it seems necessary to erect a new subgenus, *Leptocytheridea*, to which four of the new species and one new variety here described are assigned. The small, delicate species embraced within the new subgenus are more limited in number than those of the other two subgenera.

Through the courtesy of Dr. Henry V. Howe, Director of the School of Geology, Louisiana State University, I have had access to the original samples upon which the Chickasawhay report was based, as well as numerous other samples from the Gulf Coast Tertiary. My thanks are extended to Doctor Howe for his willing coöperation in furnishing samples, for helpful suggestions while the study was in progress, and for criticism of the completed manuscript.

The type specimens upon which this report is based have been deposited in the Henry V. Howe collection, Louisiana State University, Baton Rouge, Louisiana. The localities from which specimens were obtained are described at the end of the paper.

All illustrations were drawn by the author.

SYSTEMATIC DESCRIPTIONS

Family CYTHERIDAE Baird, 1850

Genus CYTHERIDEA Bosquet, 1852

Subgenus HAPLOCYTHERIDEA Stephenson, 1936

CYTHERIDEA (HAPLOCYTHERIDEA) BLANPIEDI Stephenson

Plate 26, figure 10

Cytheridea sp. 3, HOWE, *1934*, Guide Book, Eleventh Annual Field Trip of Shreveport Geol. Soc.

Cytheridea blanpiedi STEPHENSON (MS.), *1936*, Louisiana Dept. Cons., Geol. Bull. 7, p. 31, pl. 2, fig. 15.

Cytheridea (*Haplocytheridea*) *blanpiedi* STEPHENSON, *1936*, Jour. Paleontology, vol. 10, pp. 701, 702, pl. 94, figs. 11, 12; text-figs. 1*e*, *f*, *m*, *n*.

This species was recorded by me from the Bryam marl (Oligocene) of Alabama. The present study of the species has shown it to range from the older Red Bluff through the lower and upper Chickasawhay members of the Catahoula, at Locs. 7 to 11. The figured specimen is from the lower Chickasawhay.

Length 0.75 mm.; height 0.46 mm.; width 0.36 mm.

Type.—Hypotype, H. V. Howe Coll., No. 1504, from Loc. 7.

CYTHERIDEA (HAPLOCYTHERIDEA) CHAMBERSI Stephenson, n. sp.

Plate 26, figure 2; text-figures 13, 22

Carapace small, tumid, rather heavy; in side view subovate, with the left valve higher and more rounded than the right. Dorsal margin gently arched in the left valve, ventral margin somewhat convex; anterior and posterior ends well rounded, the latter slightly narrower. Right valve lower, sloping to the somewhat rounded postero-ventral angle. Surface entirely smooth. Hinge in the right valve with notched, terminal dental

areas, between which is a row of fine crenulations. In the left valve, hinge consisting of corresponding notched sockets, with a shallow, crenulate furrow joining them, terminated below by a slender bar, and above by the low, rounded dorsal margin. Marginal area broad on the anterior, with the line of concrescence about midway between inner and outer margins. About 30 radial pore canals are present on the anterior. The muscle scar pattern consists of a vertical row of four small scars, with two more in front of them, the lower of which is elongate and oblique, the upper larger and crescent shaped (text-fig. 22).

Length (left valve) 0.62 mm.; height 0.35 mm.

This species is named in honor of Mr. Jack Chambers, of Houston, Tex., junior author of *Louisiana Jackson Eocene Ostracoda*.

Occurrence.—*C.* (*Haplocytheridea*) *chambersi* is present in my collections only from the basal portion of the Moody's Branch marl of the Jackson Eocene. It is described from Loc. 1, but I also have specimens from the transition zone below the Moody's Branch marl at Garland Creek, Clarke County, Miss.

Types.—Syntypes, H. V. Howe coll., nos. 1482, 1483.

CYTHERIDEA (HAPLOCYTHERIDEA) CHAMBERSI Stephenson var. GRANULOSA Stephenson, n. var.

This variety differs from the typical form only in the very fine, closely spaced pits, which are visible over the entire exterior of the carapace, giving the surface a somewhat granular appearance under higher magnifications.

Length (left valve) 0.58 mm.; height 0.35 mm.

Occurrence.—The variety occurs with the typical species in the basal Jackson Eocene at Loc. 1, from which it is described.

Types.—Syntypes, H. V. Howe coll., nos. 1484, 1485.

EXPLANATION OF TEXT-FIGURES 1–27

(All figures ×75, unless otherwise indicated)

FIGS. *1, 2, 9, 10, 11, 21*—*Cytheridea* (*Haplocytheridea*) *watervalleyensis* Stephenson, n. sp. *1*, Hinge of right valve. *2*, Hinge of left valve. *9*, Muscle scar pattern of left valve, ×150. *10, 11*, Posterior and anterior marginal areas, showing radial pore canals. *21*, Dorsal view, ×45. (p. 153)

3, 4, 7, 15, 16, 27—*Cytheridea* (*Clithrocytheridea*) *howei* Stephenson, n. sp. *3*, Hinge of right valve. *4*, Hinge of left valve. *7*, Muscle scar pattern of a right valve, ×150. *15, 16*, Posterior and anterior marginal areas. *27*, Dorsal view, ×45. (p. 155)

5, 6—*Cytheridea* (*Leptocytheridea*) *fragillissima* Stephenson, n. sp. *5*, Hinge of left valve. *6*, Hinge of right valve. (p. 157)

8—*Cytheridea* (*Haplocytheridea*) *hazzardi* Stephenson, n. sp. Dorsal view, ×45. (p. 151)

12, 24—*Cytheridea* (*Haplocytheridea*) *danvillensis* Stephenson, n. sp. *12*, Dorsal view of left and right valves, showing articulation of hinge, ×60. *24*, Anterior marginal area of right valve. (p. 148)

13, 22—*Cytheridea* (*Haplocytheridea*) *chambersi* Stephenson, n. sp. *13*, Anterior marginal area of left valve. *22*, Muscle scar pattern of left valve, ×150. (p. 147)

14—*Cytheridea* (*Leptocytheridea*) *wailesi* Stephenson, n. sp. Marginal area of left valve. (p. 158)

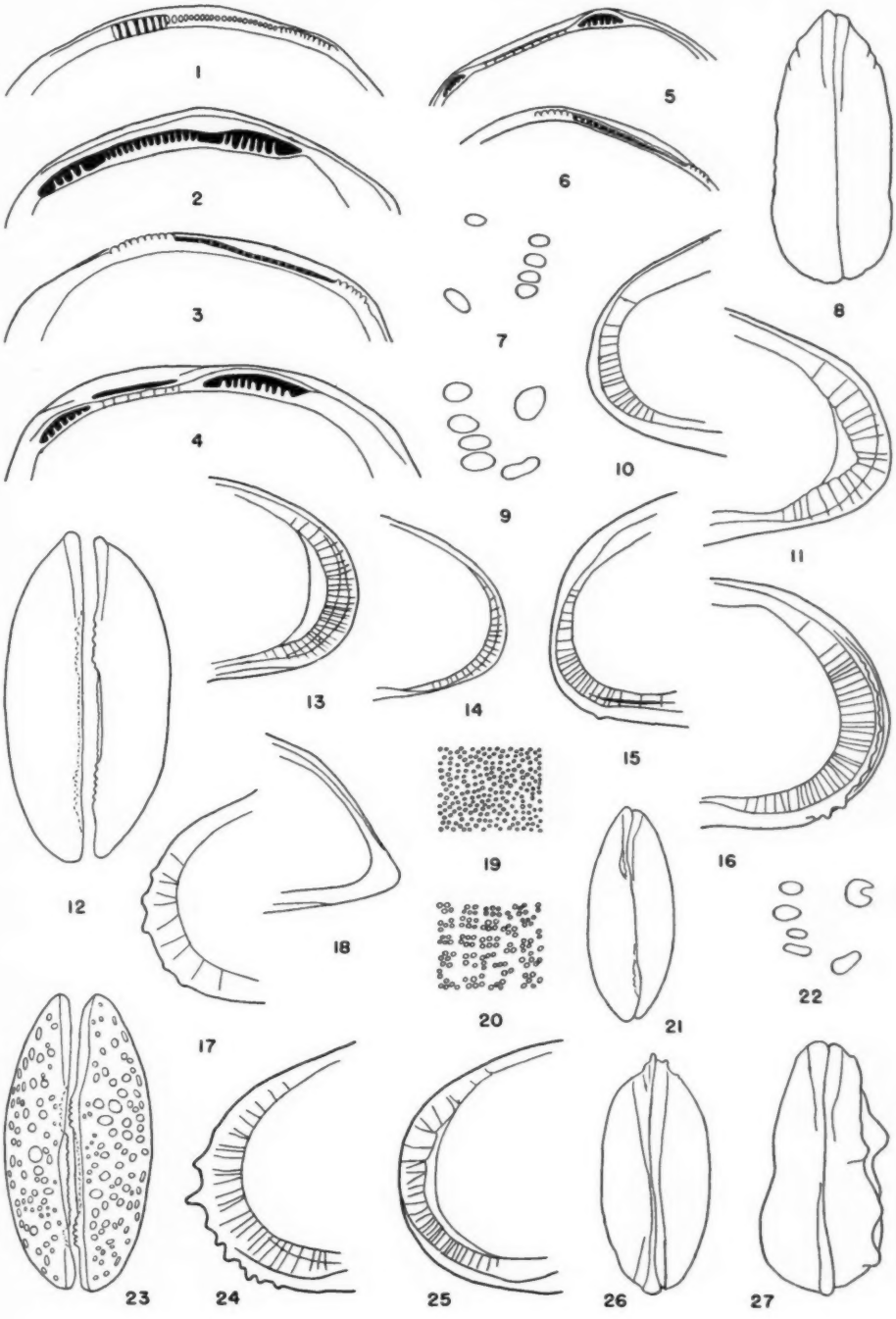
17, 18—*Cytheridea* (*Haplocytheridea*) *hiwanneensis* Stephenson, n. sp. Anterior and posterior marginal areas of right valve. (p. 151)

19—*Cytheridea* (*Clithrocytheridea*) *grigsbyi* Howe and Chambers. Pitting pattern on exterior of carapace. (p. 155)

20—*Cytheridea* (*Clithrocytheridea*) *grigsbyi* Howe and Chambers var. *jacksonensis* Stephenson, n. var. Pitting pattern on exterior of carapace. (p. 155)

23—*Cytheridea* (*Clithrocytheridea*) *shubutensis* Stephenson, n. sp. Dorsal view of left and right valves, showing articulation of hinge, ×60. (p. 156)

25, 26—*Cytheridea* (*Haplocytheridea*) *ouachitensis* Stephenson, n. sp. *25*, Anterior marginal area of right valve. *26*, Dorsal view, ×45. (p. 153)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CYTHERIDEA (HAPLOCYTHERIDEA) DANVILLENSIS Stephenson, n. sp.
Plate 26, figure 7; Text-figures 12, 24

Carapace in side view subpyriform, highest slightly anterior to the middle. Dorsal margin gently arched, flattened along the hinge line; ventral margin convex in the left valve, nearly straight in the right valve. Anterior end broadly and evenly rounded, often bearing several short, blunt spines; posterior sloping steeply to the rounded postero-ventral angle, which usually carries several similar spines on the right valve. Entire surface closely and evenly covered with pits of moderate size, the pitting being most prominent on the inflated portion of the carapace. A slightly intrenched sulcus is often visible, extending from the median dorsal portion of the shell obliquely toward the ventral and anterior; one or more additional parallel furrows may also be slightly developed. Hinge in the right valve composed of elongate, strongly notched dentitions, with a projecting line of fine crenulations between them, which is separated from the dorsal margin by a narrow, well incised line. In the left valve, hinge with well intrenched, notched, terminal sockets, which are continuous with a crenulate, connecting groove. The groove is shallow in the central portion of the hinge, where there is a slight bar above it, which is in turn separated from the dorsal margin by a faintly incised line. Marginal areas of moderate width, with the line of concrescence coinciding with the inner margin throughout. Radial pore canals slightly wavy, somewhat irregularly spaced, about thirty in number on the anterior. Muscle scar pattern typical for the genus.

Length 0.81 mm.; height 0.50 mm.; width 0.37 mm.

Remarks.—*C.* (*H.*) *danvillensis* bears a strong outward resemblance to *C.* (*H.*) *blanpiedi* (pl. 26, fig. 10), an Oligocene species. The new species is distinct in its surface sculpture, the pits being smaller, more closely spaced, and covering the entire surface of the carapace, while *C.* (*H.*) *blanpiedi* becomes smooth on the posterior slope, and the noticeable absence of pits extends around the entire peripheral area. The new Eocene species has about 30 radial pore canals on the anterior, while the Oligocene form has about 40 canals.

Occurrence.—Lower bed, Jackson Eocene, at Danville Landing, Loc. 4.

Types.—Holotype, H. V. Howe coll., no. 1488; paratypes, nos. 1489, 1490.

CYTHERIDEA (HAPLOCYTHERIDEA) EHLERSI Howe and Stephenson
Plate 26, figure 6

Cytheridea ehlersi HOWE and STEPHENSON (part), *1935*, Louisiana Dept. Cons., Geol. Bull. 5, pp. 12, 13, pl. 1, fig. 10; pl. 2, figs. 16, 21; *not* pl. 2, fig. 19.

This species is here re-figured for subgeneric assignment. The hinge structure is typical for the subgenus *Haplocytheridea*, and as originally described consists in the right valve of

a prominent, crenulated area at each cardinal angle, between which the dorsal margin is faintly crenulate. The hinge of the left valve consists of deep, pitted sockets at the cardinal angles connected by a fairly deep, crenulate groove. This groove is flanked above by a well-defined ridge, which in turn is separated from the dorsal margin by a broad depressed area.

Muscle scar pattern typical for the genus.

The original figure of this pattern (Howe and Stephenson, 1935, pl. 2, fig. 19) was drawn from paratype no. 1123, H. V. Howe coll., which specimen is here referred to *C.* (*H.*) *ouachitensis*, n. sp.

Length 0.77 mm.; height 0.44 mm.; width 0.35 mm.

Occurrence.—Upper bed, Jackson Eocene, at Loc. 5, Danville Landing, La.

Types.—Hypotypes, H. V. Howe coll., nos. 1491–1493.

CYTHERIDEA (HAPLOCYTHERIDEA) HADLEYI Stephenson, n. sp.
Plate 26, figure 16

Carapace small, tumid, in side view subpyriform; left valve much higher than the right. Dorsal margin gently arched, ventral margin nearly straight. Anterior

end broadly rounded, posterior end more narrowly rounded in the left valve, gently tapering to the rounded postero-ventral angle in the right valve. Entire surface covered with fairly numerous, shallow pits of moderate size, the area between them being very finely pitted, giving the carapace a somewhat granular appearance under high magnifications. Hinge in the right valve possesses elongate dentitions, faintly notched to form about five cusps, with a line of very fine crenulations between them. Hinge in the left valve with corresponding terminal sockets, connected by a faintly incised, crenulate groove. Marginal area fairly broad, especially on the anterior, showing numerous simple radial pore canals. Muscle scars six in number, four in a vertical row, the uppermost of which is somewhat removed, and two elongate, oblique scars anterior to them, all of which are usually distinguishable from the exterior.

Length (right valve) 0.63 mm.; height 0.31 mm.

Named in honor of Mr. Wade H. Hadley, Jr., of Ft. Worth, Tex., student of the Jackson beds, who collected fossils from Loc. 1 with me.

Occurrence.—This species, like *C.* (*H.*) *chambersi*, has been observed by me only in the basal portion of the Moody's Branch marl of the Jackson Eocene. Figured specimens are from Loc. 1. I also have specimens from the transition zone below the Moody's Branch marl at Garland Creek, Clarke County, Miss.

Types.—Syntypes, H. V. Howe coll., nos. 1486, 1487.

CYTHERIDEA (HAPLOCYTHERIDEA) HAZZARDI Stephenson, n. sp.

Plate 26, figure 15; Text-figure 8

Cytheridea sp. 6, HOWE, *1934*, Guide Book, Eleventh Annual Field Trip of Shreveport Geol. Soc., pl. 1, figs. 15, 16.

Carapace heavy, tumid, in side view subovate, anterior cardinal angle slightly higher than the posterior. Anterior end broadly rounded, passing in a smooth curve into the subparallel dorsal and ventral margins. Posterior end well rounded, somewhat narrower than the anterior, and very strongly inflated. A vertical median depression of variable extent and shape extends obliquely from a point near the dorsal margin to the center of the carapace. Entire surface covered with large, deep pits, which are set in several curvilinear furrows on the anterior and ventral sides, nearly parallel to the periphery of the valve. Hinge in the right valve composed of terminal dentitions divided into about five cusps, joined by a narrow, notched bar. In the left valve, hinge with corresponding notched sockets, with a crenulate groove between and continuous with them. Marginal area of moderate width, with the line of concrescence coinciding with the inner margin throughout. About 35 simple radial pore canals are present on the anterior. Muscle scar pattern a vertical row of four small scars, with two more elongate, oblique scars anterior to them.

Length 0.86 mm.; height 0.49 mm.; width 0.49 mm.

Remarks.—This species is confined to the upper Chickasawhay member of the Catahoula formation, in which it is fairly common. It is readily distinguished from *C.* (*H.*) *blanpiedi* of the Chickasawhay and Vicksburg, by its higher, more broadly rounded, strongly inflated posterior end. The holotype (pl. 26, fig. 15), is somewhat more strongly sculptured than the average specimen. Named in honor of Roy T. Hazzard, Gulf Refining Company of Louisiana, for his field studies of the Chickasawhay.

Occurrence.—Upper Chickasawhay member of the Catahoula formation, Wayne County, Mississippi, Locs. 7–9.

Types.—Holotype, H. V. Howe coll., no. 1501; paratypes, nos. 1502, 1503; all from Loc. 9.

CYTHERIDEA (HAPLOCYTHERIDEA) HIWANNEENSIS Stephenson, n. sp.

Plate 26, figure 18; Text-figures 17, 18

Carapace tumid, in side view elongate, subpyriform, highest slightly anterior to

the middle. Anterior end well rounded, usually bearing several short, blunt spines. Posterior end somewhat compressed, sloping to the pointed posteroventral angle. Dorsal margin fairly well arched, flattened along the hinge line, and sloping toward the posterior. Ventral margin nearly straight to the posteroventral angle. Surface smooth, showing very minute pitting under high magnification. A few moderate-sized pits are usually developed somewhat anterior to the middle, which may be arranged in several short, curvilinear furrows visible in the anterior half of the carapace. Hinge in the right valve consists of elongate, faintly notched dental areas, connected by a somewhat lower bar which is separated from the dorsal margin by a well incised line. In the left valve, hinge with a crenulate groove which broadens to form the notched terminal sockets, above which the dorsal margin extends as a low bar. Marginal area of moderate width, with the line of concrescence slightly inside the inner margin on the anterior. Radial pore canals few in number, about 10 to 15 on the anterior, sometimes completely absent on the posterior.

Length (right valve) 0.66 mm.; height 0.37 mm.

Remarks.—This species, which appears to be confined to the Red Bluff, shows decided affinities to *C.* (*H.*) *montgomeryensis* Howe and Chambers, from the Jackson, and is apparently derived from this species. The furrows are shorter than in the Jackson species and weakly developed or entirely absent, and there is a considerable reduction in the number of radial pore canals.

EXPLANATION OF PLATE 26

All figures ×50

FIGS. *1*—*Cytheridea* (*Clithrocytheridea*) *shubutensis* Stephenson, n. sp. Lateral view of right valve. (p. 156)

2—*Cytheridea* (*Haplocytheridea*) *chambersi* Stephenson, n. sp. Lateral view of left valve. (p. 147)

3—*Cytheridea* (*Haplocytheridea*) *watervalleyensis* Stephenson, n. sp. Right valve. (p. 153)

4—*Cytheridea* (*Haplocytheridea*) *ouachitensis* Stephenson, n. sp. Right valve. (p. 153)

5—*Cytheridea* (*Leptocytheridea*) *kellumi* Howe and Stephenson. Lateral view of right valve. (p. 157)

6—*Cytheridea* (*Haplocytheridea*) *ehlersi* Howe and Stephenson. Right valve view. (p. 150)

7—*Cytheridea* (*Haplocytheridea*) *danvillensis* Stephenson, n. sp. Right valve. (p. 148)

8—*Cytheridea* (*Leptocytheridea*) *waynensis* Stephenson, n. sp. Lateral view of right valve. (p. 158)

9—*Cytheridea* (*Clithrocytheridea*) *howei* Stephenson, n. sp. Right valve. (p. 155)

10—*Cytheridea* (*Haplocytheridea*) *blanpiedi* Stephenson. Right valve. (p. 147)

11—*Cytheridea* (*Leptocytheridea*) *wailesi* Stephenson, n. sp. Lateral view of left valve. (p. 158)

12—*Cytheridea* (*Clithrocytheridea*) *grigsbyi* Howe and Chambers var. *chickasawhayana* Stephenson, n. var. Right valve. (p. 154)

13—*Cytheridea* (*Clithrocytheridea*) *caldwellensis* Howe and Chambers. Lateral view of left valve. (p. 154)

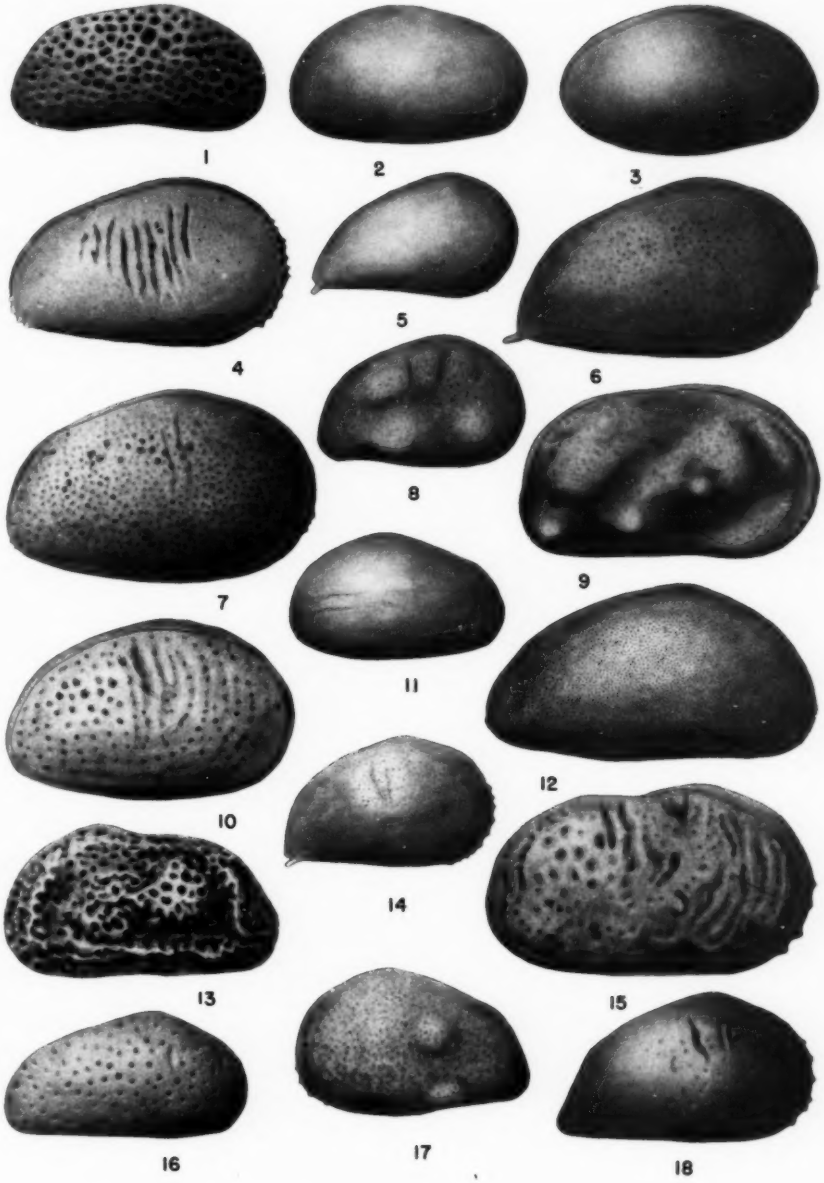
14—*Cytheridea* (*Leptocytheridea*) *fragillissima* Stephenson, n. sp. Lateral view of right valve. (p. 157)

15—*Cytheridea* (*Haplocytheridea*) *hazzardi* Stephenson, n. sp. Right valve. (p. 151)

16—*Cytheridea* (*Haplocytheridea*) *hadleyi* Stephenson, n. sp. Lateral view of right valve. (p. 150)

17—*Cytheridea* (*Leptocytheridea*) *mcguirti* Stephenson var. *mississippiensis* Stephenson, n. var. Lateral view of left valve. (p. 158)

18—*Cytheridea* (*Haplocytheridea*) *hiwanneensis* Stephenson, n. sp. Lateral view of right valve. (p. 151)



Stephenson, Tertiary Ostracodes

UNIV. OF MICH.

Occurrence.—Red Bluff, Oligocene, at Hiwannee, Miss. It is rare at Loc. 6, from which station it is described.

Types.—Holotype, H. V. Howe coll., no. 1519; paratype, no. 1520.

CYTHERIDEA (HAPLOCYTHERIDEA) MONTGOMERYENSIS Howe and Chambers

Cytheridea montgomeryensis HOWE and CHAMBERS, *1935*, Louisiana Dept. Cons., Geol. Bull. 5, pp. 17, 18, pl. 1, fig. 1; pl. 2, figs. 1–3, 7, 9; pl. 6, figs. 17, 18.

Cytheridea (*Haplocytheridea montgomeryensis* STEPHENSON, *1936*, Jour. Paleontology, vol. 10, pp. 700, 701, pl. 94, fig. 9; text-figs. 1*g*, *h*, *j*, *k*.

In the collections which I have had available for study, *C.* (*H.*) *montgomeryensis* has been plentiful from nearly all middle and lower Jackson localities. It has not been found, however, in any sample carrying *Massilina pratti*, and does not appear to be present in that zone of the Jackson in central Mississippi, across Louisiana to Texas, where it appears to be replaced by *C.* (*H.*) *danvillensis*, *C.* (*H.*) *ehlersi*, and *C.* (*H.*) *ouachitensis*. Throughout this region, these three species likewise have not been found to extend down into the portion of the column occupied by *C.* (*H.*) *montgomeryensis*. In eastern Mississippi, however, in beds immediately underlying the Red Bluff, Oligocene, which carry the foraminiferal fauna described by Cushman as the "Cocoa sand" assemblage, what appears to be *C.* (*H.*) *montgomeryensis* occurs abundantly with *C.* (*H.*) *ehlersi* and *C.* (*H.*) *ouachitensis*. The specimens at this locality are somewhat more coarsely pitted and more strongly spinose than is customary in the lower Jackson, but I do not feel safe in suggesting that they possess even varietal difference. The range of the species, therefore, apparently must be throughout all of Jackson time, even though it has not been found in upper Jackson samples from the center of the Mississippi embayment.

CYTHERIDEA (HAPLOCYTHERIDEA) OUACHITENSIS Stephenson, n. sp.

Plate 26, figure 4; Text-figures 25, 26

Cytheridea ehlersi HOWE and STEPHENSON (part), *1935*, Louisiana Dept. Cons., Geol. Bull. 5, pp. 12, 13, pl. 2, fig. 19; *not* pl. 1, fig. 10; pl. 2, figs. 16, 21.

Carapace in side view subpyriform; males somewhat more elongate and less inflated posteriorly. Dorsal margin gently arched, highest at the anterior one-third the shell length; ventral margin slightly convex. Anterior end broadly and evenly rounded; posterior end sloping steeply to the well rounded postero-ventral angle. Several very short, blunt spines are sometimes visible on the ventral half of the anterior end, and similar spines may occur at the postero-ventral angle. Surface smooth, except for four to six irregular vertical furrows in the central portion of the dorsal half of the carapace. The furrows are readily distinguishable on most specimens, and sometimes show a tendency to be pitted; occasionally the entire carapace is almost smooth. Hinge in the right valve possesses slightly notched, terminal dental areas, which merge with a slender connecting bar. In the left valve, hinge with elongate, notched sockets, with a very slender, faintly crenulate groove between them, which lies immediately below the projecting edge of the dorsal margin. Marginal area of moderate width, with the line of concrescence somewhat inside the inner margin on the anterior. About 30 radial pore canals are present on the anterior, which are simple, somewhat wavy, and irregularly disposed. Muscle scar pattern typical for the genus.

Length 0.72 mm.; height 0.41mm.; width 0.32 mm.

Remarks.—This species was not originally differentiated from *C.* (*H.*) *ehlersi* Howe and Stephenson, with which it occurs at the type locality. The vertical furrows and absence of pronounced pitting readily distinguish it from *C.* (*H.*) *ehlersi*.

Occurrence.—I have observed this new species only in Jackson Eocene material from the upper and lower beds at Danville Landing on the Ouachita River, Louisiana.

Types.—Holotype, H. V. Howe coll., no. 1479; paratypes, nos. 1480, 1481; from the upper bed at Loc. 4.

CYTHERIDEA (HAPLOCYTHERIDEA) WATERVALLEYENSIS Stephenson, n. sp.
Plate 26, figure 3; Text-figures 1, 2, 9–11, 21

Carapace tumid, in side view ovate, with the greatest height at about the middle. Dorsal margin gently arched, passing in a smooth curve into the well rounded anterior and posterior ends; posterior end somewhat narrower than the anterior. Ventral margin nearly straight in the right valve, convex in the left. Entire surface smooth, showing fairly numerous normal pore canals. Hinge in the right valve consists of dental areas notched into about six cusps, which are joined by a lower line of fine crenulations. In the left valve, hinge with strong, deeply notched sockets, connected by a shallow, crenulate groove, above which the dorsal margin extends as a low bar. Marginal area fairly broad on the anterior, broken by a sharp-edged shelf, outside of which the marginal area of the shell to the periphery is lower. The line of concrescence coincides with the inner margin except on the anterior, where it swings out abruptly into the marginal area to a point nearly midway between inner and outer margins (text-fig. 11). About 20 simple radial pore canals are present on the anterior. The ventral margin of the left valve is thickened, and strongly overlaps the right valve. The interior of the carapace wall is thickened, forming shallow anterior and posterior cavities. Six muscle scars are visible, four of which are arranged in an irregular vertical row, with two more larger scars in front of them.

Length of holotype 0.67 mm.; height 0.38 mm.; width 0.27 mm.

Occurrence.—*C.* (*H.*) *watervalleyensis* is common in the lower Jackson of Alabama and Mississippi, but is rare in Louisiana samples.

Types.—Holotype, H. V. Howe coll., no. 1474, from Loc. 5; paratypes, nos. 1475, 1476, from Loc. 3.

CYTHERIDEA (HAPLOCYTHERIDEA) WATERVALLEYENSIS Stephenson var. LAWI Stephenson, n. var.

This variety differs from the typical form in possessing fine, closely spaced pits over the entire exterior of the carapace. The variety and typical species are identical except for this feature, and have been found by me to occur together in the same samples in localities from the lower Jackson.

Length (left valve) 0.83 mm.; height 0.49 mm.

The variety is named in honor of John Law, student of the Vicksburg Ostracoda at Louisiana State University.

Types.—Syntypes, H. V. Howe coll., nos. 1477, 1478, from Loc. 1.

Subgenus CLITHROCYTHERIDEA Stephenson, 1936

CYTHERIDEA (CLITHROCYTHERIDEA) CALDWELLENSIS Howe and Chambers
Plate 26, figure 13

Cytheridea ? caldwellensis HOWE and CHAMBERS, *1935*, Louisiana Dept. Cons., Geol. Bull. 5, pp. 11, 12, pl. 1, fig. 7; pl. 2, figs. 4–6.

This species is here included for subgeneric assignment. The original description of the hinge, which is of the *Clithrocytheridea* type, is quoted.

Hinge line straight. In the left valve the hinge consists of a finely crenulate ridge outlined dorsally by an incised line. At either end of the ridge is an elongate, crenulate pit. In the right valve there is a straight, long, narrow, crenulate groove in the edge of the dorsal margin, at either end of and below which is a prominent projecting cusp bearing five or six small crenulations.

Length (left valve) 0.71 mm.; height 0.38 mm.

Occurrence.—This distinctive species

has been observed by me only from the Moody's Branch marl of the lower Jackson, Eocene. A single valve, having the appearance of a reworked specimen, was encountered in the Red Bluff.

Types.—Hypotypes, H. V. Howe coll., nos. 1496, 1497, from Loc. 1.

CYTHERIDEA (CLITHROCYTHERIDEA) GRIGSBYI Howe and Chambers var. CHICKASAWHAYANA Stephenson, n. var.

Plate 26, figure 12

Cytheridea sp. 1, HOWE, *1934*, Guide Book, Eleventh Annual Field Trip of Shreveport Geol. Soc.

This variety differs from the typical form in having much smaller pits, which are more closely spaced and cover the entire exterior of the carapace, giving it a somewhat granular appearance. The normal pore canals, the exterior extremities of which are flush with the outer surface of the valves in the typical species, are marked by distinct, fairly large pits in the variety. In adult specimens, the dorsal margin is fairly strongly arched to a maximum height at the anterior cardinal angle, and flattened along the hinge line. The hinge structure is similar to the typical, except for the depressed area separating the bar between the sockets from the dorsal margin in the left valve, which is weakly developed. In the right valve, the dorsal margin is very low above the groove between the terminal dental areas.

Length 0.86 mm.; height 0.44 mm.; width 0.39 mm.

Remarks.—The new variety is distinct from *C.* (*C.*) *grigsbyi* var. *vicksburgensis* Stephenson, from the Byram marl, Oligocene. While the outline is very similar in side view, the carapace of the new variety is heavier, the pits are much finer, and the larger pits marking the normal pore canals are distinctive.

Occurrence.—This variety is common in both members of the Chickasawhay. Figured specimens are from Loc. 7.

Types.—Holotype, H. V. Howe coll., no. 1505; paratypes, nos. 1506, 1507.

CYTHERIDEA (CLITHROCYTHERIDEA) GRIGSBYI Howe and Chambers var. JACKSONENSIS Stephenson, n. var.

Text-figure 20

This variety differs from the typical species only in the pattern of the pitting on the exterior of the carapace. The typical species is thickly covered with fine, equally spaced pits (text-fig. 19, hypotype, no. 1498, of *C.* (*C.*) *grigsbyi* Howe and Chambers, from Loc. 1, used for this drawing). In the new variety, the pits are fewer in number, and are arranged in groups of about six pits, each group being isolated from neighboring groups by narrow, unpitted areas (text-fig. 20). This pattern is most prominent on the inflated portion of the carapace wall. Typical species and variety are identical with respect to all other shell characters.

Length (right valve) 0.69 mm.; height 0.34 mm.

Occurrence.—Basal Jackson at Loc. 1, from which station the variety is described. It occurs here in association with the typical species.

Types.—Holotype, H. V. Howe coll., no. 1499 (right valve); paratype, no. 1500.

CYTHERIDEA (CLITHROCYTHERIDEA) HOWEI Stephenson, n. sp.

Plate 26, figure 9; Text-figures 3, 4, 7, 15, 16, 27

Carapace heavy, in side view subovate, anterior cardinal angle slightly higher than the posterior. Anterior end broadly and evenly rounded, bearing about ten short, blunt spines on the ventral half of the right valve, with a fewer number on the left valve. Anterior end passes in a smooth curve into the subparallel dorsal and ventral margins, which converge slightly toward the posterior. Posterior end nearly vertical in most specimens, producing almost a right angle at the postero-ventral angle. Entire surface somewhat rough, with closely spaced, very shallow pits and irregular depressions. The major sculpturing superimposed on this is very pro-

nounced in the right valve, and entirely absent in the left valve (text-fig. 27). In the right valve, a small, subspherical node is visible, very near the postero-ventral angle. A second less prominent node is situated somewhat anterior to it, with a third, more broadly rounded elevation in front of it and higher on the carapace wall. The area adjacent to the posterior cardinal angle is strongly inflated, producing a broad depression in the central portion of the valve between it and the anterior of the three nodes. Slight dorsal and ventral thickenings of the carapace wall are visible on the anterior end, with a depressed area between and posterior to them. Nodular inflations absent on the left valve, which is very strongly inflated in the dorsal portion of the posterior end. Hinge in the right valve with elongate, notched dentitions sloping into a lower, slightly grooved connecting line of crenulations. In the left valve, hinge composed of deeply incised, notched sockets, connected by a bar which is somewhat overhanging toward the interior of the carapace, and is separated from the dorsal margin by a shallow depressed area. Marginal area of moderate width, carrying about thirty radial pore canals on the anterior. Muscle scar pattern typical for the genus.

Length 0.76 mm.; height 0.43 mm.; width 0.39 mm.

The species is named in honor of Henry V. Howe, Director of the School of Geology, Louisiana State University, who so generously assisted in the preparation of this report.

Occurrence.—*C.* (*C.*) *howei* is confined to the upper Chickasawhay member of the Catahoula Miocene, and is an excellent index fossil for this horizon.

Types.—Holotype, H. V. Howe coll., no. 1512; paratypes, nos. 1513, 1514; from Loc. 9.

CYTHERIDEA (CLITHROCYTHERIDEA) SHUBUTENSIS Stephenson, n. sp.
Plate 26, figure 1; Text-figure 23

Carapace in side view subreniform, highest somewhat anterior to the middle. Dorsal margin weakly arched, subparallel to the slightly indented ventral margin. Anterior end broadly and obliquely rounded, posterior end sloping steeply to the rounded postero-ventral angle. Entire surface covered with large, deep, closely spaced, subcircular pits. Hinge in the right valve composed of slightly elevated dental areas, notched into about five cusps, connected by a deep, crenulated trench, above which the dorsal margin extends as a low bar. In the left valve, hinge with corresponding notched sockets, with an elevated, crenulate bar joining them, separated from the dorsal margin by a faintly incised line. A faint lip line is visible on the posterior half of the ventral margin of the left valve. Marginal areas of moderate width, with about twenty simple radial pore canals on the anterior.

Length (right valve) 0.67 mm.; height 0.34 mm.

Remarks.—The hinge structure of this species must be carefully observed to insure proper generic assignment. An undescribed species of *Cythereis*, almost exactly similar from the exterior in regard to shape and ornamentation, can be differentiated only on the basis of the hinge line.

Occurrence.—This species is rather rare in the Jackson, having been observed by me only in the lower part of the Moody's Branch marl, at Locs. 1 and 3. Figured specimens are from the Cocoa sand at Loc. 3.

Types.—Syntypes, H. V. Howe coll., nos. 1472, 1473.

Subgenus LEPTOCYTHERIDEA Stephenson, n. subgen.

Subgenotype: *Cytheridea* (*Leptocytheridea*) *fragillissima* Stephenson.

Carapace thin and small for the genus; in side view subpyriform, about one and one-half times as long as high, with the greatest height somewhat anterior to the middle. Dorsal and ventral margins converge to the posterior; anterior end well rounded, posterior end steeply sloping to the acute or somewhat rounded postero-ventral angle. One or both valves may

bear short spines on the ventral half of the anterior end, which are usually better developed in the right valve when present. A single longer, blunt spine at the postero-ventral angle of the right valve, sometimes flanked by several short spines, occurs in a number of species. Surface smooth, pitted, or rather weakly ornamented. Hinge structure slender and very delicate. The right valve possesses terminal taxodont dental areas, cut into about six dentitions, which are truncated into a narrow, crenulate, connecting groove, which is terminated dorsally by the low dorsal margin, rising as a slender bar above it. The complimentary hinge line of the left valve is made up of notched sockets corresponding to the terminal teeth of the right valve, between which is a slender, finely notched bar, usually separated from the dorsal margin by a faintly incised line. Marginal areas usually narrow, carrying a moderate number of simple, fairly straight radial pore canals. Muscle scar pattern characteristic for the genus, consisting of four ovoid scars vertically situated in a row, often arcuate, with two additional, obliquely elongate scars anterior to them.

Remarks.—The extreme delicacy of shell structure of this subgenus, with its weakly ornamented exterior, distinguishes it from the subgenus *Clithrocytheridea*, which possesses a very heavy, usually strongly sculptured carapace. The hinge structure of the two subgenera show decided affinities. It is distinct from the subgenus *Haplocytheridea* in the characteristics of the hinge line, and in its ordinarily smaller, more fragile carapace.

The range of *Leptocytheridea*, as observed by me, is Eocene to Recent.

CYTHERIDEA (LEPTOCYTHERIDEA) FRAGILLISSIMA Stephenson, n. sp.

Plate 26, figure 14; Text-figures 5, 6

Cytheridea sp. 2, HOWE, *1934*, Guide Book, Eleventh Annual Field trip of Shreveport Geol. Soc.

Carapace small, thin, in side view subpyriform, highest and thickest slightly anterior to the middle. Dorsal margin weakly arched, with weak cardinal angles; ventral margin almost straight in the left valve, slightly concave in the right valve. Anterior end broadly rounded, often bearing several very short, blunt spines in the right valve. Posterior end sloping steeply to the somewhat rounded postero-ventral angle, which usually bears one fairly long, slender spine in the right valve. Entire surface covered with closely spaced, very fine pits, with a faintly defined, slightly oblique, median vertical sulcus usually visible, sometimes paralleled by a similar depression. Hinge structure very delicate; in the right valve composed of slender terminal dentitions, notched to form about six cusps. A narrow, crenulate groove extends between the dental areas, becoming obscure near the posterior dentition. The groove is bounded dorsally by the faintly defined dorsal margin. In the left valve, hinge with notched terminal sockets, connected by a narrow, crenulate bar, which is separated from the dorsal margin by a shallow depressed area. Marginal areas very narrow, carrying about fifteen simple radial pore canals on the anterior, and about half that number on the posterior.

Length of syntype (right valve) 0.56 mm.; height 0.33 mm.; length (left valve) 0.58 mm.; height 0.35 mm.

Remarks.—*C.* (*L.*) *fragillissima* is closely related to *C.* (*L.*) *byramensis* Stephenson, a species recently described (Stephenson, 1936) from the Byram marl, Oligocene. It is most easily distinguished from the Oligocene form by the presence of surface pitting. A third similar species, *C.* (*L.*) *choctawhatcheensis* Howe and Stephenson from the *Arca* zone of the Choctawhatchee, Miocene (see Howe and Stephenson, 1935*a*), is distinct from the two above-mentioned species in having a much higher posterior cardinal angle, with a much more steeply sloping posterior end.

Occurrence.—This species is fairly common in the lower and upper Chickasawhay beds. The figured specimens are from Loc. 8.

Types.—Syntypes, H. V. Howe coll., nos. 1508, 1509, from Loc. 8.

CYTHERIDEA (LEPTOCYTHERIDEA) KELLUMI
Howe and Stephenson
Plate 26, figure 5

Cytheridea kellumi HOWE and STEPHENSON, *1935*, Louisiana Dept. Cons., Geol. Bull. 5, p. 16, pl. 1, fig. 11; pl. 2, figs. 13–15.

This small, fragile, smooth species occurs at most Jackson Eocene localities. The hinge is exceedingly slender and delicate, consisting in the right valve of slightly raised dental areas, between which is a narrow, depressed line of crenulations. In the left valve the hinge possesses elongate, faintly notched sockets, with a slightly raised bar between them, separated from the dorsal margin by a faintly incised line. A slight groove is visible for a short distance in front of the posterior socket and below the bar.

Length (right valve) 0.55 mm.; height 0.31 mm.

Types.—Hypotypes, H. V. Howe coll., nos. 1494, 1495, from Loc. 2.

CYTHERIDEA (LEPTOCYTHERIDEA) MCGUIRTI
Stephenson var. MISSISSIPPIENSIS
Stephenson, n. var.
Plate 26, figure 17

This variety differs from the typical form in the surface pitting on the exterior of the carapace, the pits being very much finer and very closely spaced. The slight development of nodes, often present on the typical species as well as the variety, is a variable feature in both, and may be entirely lacking.

Length (left valve) 0.60 mm.; height 0.35 mm.

Occurrence.—The new variety has been observed by me only at Loc. 6 in the Red Bluff Oligocene, from which it is described.

Types.—Syntypes, H. V. Howe coll., nos. 1517, 1518.

CYTHERIDEA (LEPTOCYTHERIDEA) WAILESI
Stephenson n. sp.
Plate 26, figure 11; Text-figure 14

Carapace small, fragile, in side view subpyriform. Dorsal margin gently arched; ventral margin slightly convex. Anterior end broadly and obliquely rounded; posterior end sloping steeply to the rounded postero-ventral angle. Surface smooth. Hinge in the right valve possesses narrow, faintly notched dentitions, between which is a low line of fine crenulations. In the left valve, hinge with terminal notched sockets, connected by a somewhat elevated, slender bar, which is separated from the dorsal margin by an incised line. Marginal area very narrow, carrying about fifteen to twenty short, straight, radial pore canals. Muscle scar area identical with that of *C.* (*H.*) *chambersi.*

Length (left valve) 0.56 mm.; height 0.31 mm.

Remarks.—This lower Jackson species is somewhat similar to *C.* (*H.*) *chambersi*, but is more fragile, the hinge is much more slender, and is of the *Leptocytheridea* type. *C.* (*L.*) *wailesi* likewise has fewer radial pore canals, and the marginal area is much narrower.

Occurrence.—Lower Jackson, Eocene, Mississippi.

Types.—Holotype, H. V. Howe coll., no. 1496 (left valve), from Loc. 3; paratype, no. 1497 (right valve), from Loc. 1.

CYTHERIDEA (LEPTOCYTHERIDEA) WAYNENSIS
Stephenson, n. sp.
Plate 26, figure 8

Cytheridea sp. 5, HOWE, *1934*, Guide Book, Eleventh Annual Field Trip of Shreveport Geol. Soc., pl. 1, fig. 10.

Carapace small, in side view subpyriform, highest just anterior to the middle. Dorsal margin weakly arched, ventral margin slightly convex. Anterior end broadly rounded, often bearing about twelve short, blunt spines on the ventral half of the right valve. Surface finely and evenly pitted. Three prominent nodes are present on all specimens, two vertically situated, one above the other, at the posterior one-third of the length of the shell, and the third anterior to them, the three nodes roughly forming the apices of an equilateral triangle. Several smaller nodes are usually developed, their size and position being somewhat variable. Hinge in the right valve composed of elongate, notched dental areas, which are

gently truncated into a slender, finely crenulate groove immediately below the dorsal margin. In the left valve, hinge with notched, terminal sockets, between which is a bar which is highest at its midpoint, and which is separated from the dorsal margin by a faintly incised line. Marginal area very narrow, with about twenty radial pore canals on the anterior.

Length (right valve) 0.55 mm.; height 0.33 mm.

Occurrence.—This species is restricted to the upper Chickasawhay member of the Catahoula, Miocene, where it is rather rare. Figured specimens are from Loc. 8.

Types.—Holotype, H. V. Howe coll., no. 1510; paratype, no. 1511.

LOCALITIES

Loc. 1.—Basal Moody's Branch marl, lower Jackson, Eocene, as exposed on the north side of Town Creek where it is crossed by the Great Northern Railroad bridge, Jackson, Miss. The foraminiferal fauna of this locality includes numerous large species of the Miliolidae. The ostracode genus *Cytheridea* is represented by several species which have not been observed by me in Louisiana. Collected by W. H. Hadley, Jr., and M. B. Stephenson.

Loc. 2.—*Textularia dibollensis* zone of the Moody's Branch marl, lower Jackson, Eocene, at Hyson Bluff on the Ouachita River, Caldwell Parish, La. Collected by W. D. Chawner.

Loc. 3.—Cocoa sand of C. W. Cooke (1933), under Shubuta Bridge over the Chickasawhay River, approximately along the north line of the NW. ¼, sec. 10, T. 10 N., R. 7 W., Clarke County, Miss. Collected by E. T. and Emil Monsour, and J. W. Lea.

Loc. 4.—Lower Jackson, Eocene, 27 feet below the Cocoa sand, on "Slick" or Keyser Hill, one-fourth of a mile west of Water Valley, Ala. Collected by H. V. Howe.

Loc. 5.—Jackson, Eocene, at Danville Landing on the Ouachita River, Catahoula Parish, La. Several species included in this report were collected from the two beds at this locality, referred to as the "Upper Horizon" and "Lower Horizon" by Howe and Wallace (1932). The upper bed is in the *Massilina pratti* zone of the upper Jackson, while the lower bed is in the *Textularia hockleyensis* zone of the middle Jackson. Upper bed collected by W. D. Chawner; lower bed by H. V. Howe.

Loc. 6.—Red Bluff, Oligocene, at Hiwannee, Miss., on the east bank of the Chickasawhay River, 250 feet west of Hiwannee Railway station, at about the center of the NE. ¼, sec. 28, T. 10 N., R. 7 W., Wayne County, Miss. The material examined was collected at the highest part of the bluff by H. V. Howe.

Loc. 7.—Lower Chickasawhay member of the Catahoula, Miocene, on the west bank of the Chickasawhay River, just above water level at an elevation of about 130 feet, in the NE. ¼ of the SW. ¼, sec. 10, T. 8 N., R. 7 W., Wayne County, Miss. Collected by H. V. Howe.

Loc. 8.—Upper Chickasawhay member of the Catahoula, Miocene, 100 feet west of center of sec. 18, T. 8 N., R. 5 W., Wayne County, Miss. Elevation, 184 feet. Collected by B. W. Blanpied.

Loc. 9.—Upper Chickasawhay member of the Catahoula, Miocene, on the southwest bank of the Chickasawhay River just above the bridge, 2 miles south of Waynesboro, in the NW. ¼ of the NW. ¼, sec. 25, T. 8 N., R. 7 W., Wayne County, Miss. Collected by B. W. Blanpied.

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